Washington State Department of
Labor & Industries

Final Cost-Benefit Analysis &
Least Burdensome Analysis

Chapter 296-67 WAC Safety Standards for Process Safety Management of Highly Hazardous Chemicals

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CHAPTER 1: BACKGROUND AND INTRODUCTION

1.1 Introduction

The purpose of this cost-benefit analysis is to identify establishments potentially affected by the process safety management (PSM) rule pertaining to petroleum refineries (chapter 296-67 WAC Part B), and to evaluate the associated costs, benefits, and economic impacts of the rule. The cost-benefit analysis also fulfills the rulemaking requirements of the Administrative Procedures Act (RCW 34.05.328 (1)(c)).

1.2 The background of this rulemaking

1.2.1 Need for an Updated Process Safety Management Standard for Petroleum Refineries

History of PSM regulation in the United States

The unexpected release of highly hazardous chemicals can be deadly, leaving profound and lasting impacts on families, businesses, and communities. The potential for such releases exists any time toxic, reactive, or flammable liquids and gases are not properly controlled. PSM is a system for managing the use of highly hazardous chemicals during plant processes and activities to prevent risk of unintentional releases and applies to various industries, including refineries.

The Occupational Safety and Health Administration's (OSHA) PSM standard is over 30 years old. Catastrophic events occurring before the adoption of OSHA's rule included: multiple major disasters occurred in Bhopal, India, in 1984, resulting in more than 2,000 deaths; an incident in October 1989 at Phillips Petroleum Company in Pasadena, Texas, resulting in 23 deaths and 132 injuries; an incident in July 1990 at BASF in Cincinnati, Ohio, resulting in two deaths; and an incident in May 1991 at IMC Sterlington, Louisiana, resulting in eight deaths and 128 injuries. The federal Clean Air Act Amendments of 1990 (CAAA) directed OSHA and the United States Environmental Protection Agency (EPA) to develop regulations to prevent accidental chemical releases. The EPA's regulations and guidance for chemical accident prevention at facilities are contained in the Risk Management Plan (RMP) rule, first adopted in 1996. The CAAA requires

coordination with the U.S. Environmental Protection Agency (EPA) to promulgate a chemical process safety standard to prevent accidental releases of chemicals that could pose a threat to employees. The RMP rule requires facilities that use extremely hazardous substances to develop a RMP, which identifies the potential effects of a chemical accident, determines the steps the facility will take to prevent an accident, and has emergency response procedures in the event an accident occurs. These plans provide valuable information to emergency response personnel to prepare for and respond to chemical emergencies in their community.

History of Washington's PSM Rule

The Washington State Industrial Safety and Health Act (WISHA) was enacted in 1973, requiring Washington's occupational safety and health laws be at least as effective as OSHA. The Department of Labor and Industries (L&I) adopted OSHA's PSM standard when it was promulgated in 1992. This federal rule, like other occupational safety and health rules, was adopted to prevent hazardous exposures/incidents to workers. Similar to the federal rule, L&I's rule applies to facilities that store, use, or manufacture large amounts of certain types of highly hazardous chemicals. Examples include refineries, ammonia refrigeration, water treatment and waste water treatment, chemical plants, and explosive manufacturers. However, since 1992, process safety industry knowledge and practices have evolved to the degree that a revision is needed and appropriate to reflect current best practices throughout the industry today.

PSM Incidents at Petroleum Refineries

According to OSHA, since the adoption of the PSM rule in 1992, no other industry sector has had as many fatal or catastrophic incidents related to the release of highly hazardous chemicals as the petroleum refining industry.[1] In Washington, two major and preventable highly hazardous chemical processing workplace fatality incidents have occurred in refineries. In 1998, six workers were killed at the former Equilon petroleum refinery in Anacortes. On the morning of April 2, 2010, an explosion and fire erupted in the Naptha Hydroheater Unit at the former Tesoro

[1] Process Safety Management for Petroleum Refineries Lessons Learned from the Petroleum Refinery Process Safety Management National Emphasis Program, OSHA 3918-08 2017. https://www.osha.gov/sites/default/files/publications/OSHA3918.pdf

Refinery in Anacortes, WA, killing seven refinery workers. This last tragedy is the worst Washington State industrial incident to date.

Chemical Safety Board Tesoro Report

L&I investigated the Tesoro explosion, both to determine compliance with the Washington rule and pursuant to RCW 49.17.260, to ascertain whether new or amended rules are needed. In addition to L&I responding to the Tesoro incident, both the EPA and the U.S. Chemical Safety Board (CSB) deployed investigative teams to the site. The mission of the CSB, which is a non-regulatory federal agency, is to conduct root cause investigations of substantive industrial chemical incidents, as well as to make recommendations to owners, industry and labor organizations, and government regulators to prevent future incidents.

In 2014, the CSB published the *U.S. Chemical Safety Board Investigation Report on the 2010 Tesoro Refinery Explosion*, which concluded that a rupture of a heat exchanger, caused by a high temperature hydrogen attack (HTHA), led to the fire and explosion. The investigation concluded that the Tesoro Anacortes Refinery failed to prevent the HTHA hazard. Additionally, state regulators lacked sufficient resources to have effective preventative oversight, and the federal standard did not adequately prevent the catastrophic events. The CSB report is focused on the PSM rule, which has broad requirements regarding management systems, as well as hazard identification and control. The PSM rule requires process hazard analyses, and in certain areas, application of industry standards or recognized and generally accepted good engineering practices (RAGAGEPs). Organizations such as the American Petroleum Institute (API), American Society for Testing and Materials (ASTM); International Society of Automation (ISA); American Society of Mechanical Engineers (ASME); and American National Standards Institute (ANSI), determine industry standards and RAGAGEPs.

A causal finding of the CSB report indicates that Washington and OSHA regulations do not do enough to force companies to follow safer practices. CSB determined this could lead to the normalization of hazardous conditions, and performing the bare minimum of investigations,

inspections, and hazard analyses to comply with regulations rather than the creation of or emphasis on a culture of safety.

Another causal finding of the report indicates that the American Petroleum Institute (API) doesn't have minimum requirements regarding HTHA control, identification, or prevention. API does have guidance that identifies materials that are not susceptible to HTHA. However, it was determined that two of the heat exchangers were made from carbon steel, which is the most susceptible material.

As the causal findings of the CSB report state, current Washington and federal PSM regulations are activity-based, requiring companies to perform hazard analyses, but not requiring companies to control hazards or to analyze whether they have effective safeguards. The CSB suggested the use of a goal-setting, performance-based regulatory scheme that would provide an improved alternative. This approach includes the demonstration of, not just written procedures for, effectively managing change in handling hazard risk and driving the risk to as low as reasonably practicable. It also includes employment of sufficient numbers of technically competent personnel to assess, verify, and intervene as necessary, as well as the implementation of continual risk reduction and performance of an effective corrosion control review that meets the goal of preventing equipment failure.

The CSB report offered recommendations on how to revise existing regulations for petroleum refineries to promote continuous process safety improvements. At a high level, these recommendations include requiring the use of inherently safer design and hierarchy of hazard controls to prevent equipment failure from HTHA, promoting continuous process safety improvements, implementing a process safety culture program, and participation in the oversight of the program.

Federal Executive Order 13650

After the West Texas fertilizer explosion in 2013, federal Presidential Executive Order 13650, "Improving Chemical Facility Safety and Security", was released. It stated that the federal

government developed and implemented numerous programs aimed at reducing safety and security risks associated with hazardous chemicals. Executive departments and agencies that have regulatory authority to further improve chemical facility safety and security in coordination with owners and operators can take additional measures. The Executive Order calls for the modernization of policies and standards by developing "options for improved chemical facility safety and security that identifies improvements to existing risk management practices through agency programs, private sector initiatives, government guidance, outreach, standards, and regulations".

California Interagency Refinery Workgroup and California Refinery PSM Rule

Another incident of note occurred in August 2012 at the Richmond, California, Chevron refinery, which endangered the lives of 19 workers and caused approximately 15,000 residents to seek medical attention for symptoms caused by refinery emissions. In response to the pipe failure and fire, California Governor Jerry Brown launched an interagency refinery working group, which concluded that "improving refinery safety is a goal strongly shared by government, industry, workers, and communities." The interagency group's report recommended that regulatory changes need to "be required as soon as possible in the state's oil refineries." These changes include implementing inherently safer systems to the greatest extent feasible, performing periodic safety culture assessments, incorporating damage mechanism hazard reviews into process hazard analyses, conducting root cause analyses after significant accidents or releases, and accounting for human factors and organizational changes.

Following extensive outreach to industry, refinery workers, community-based organizations, and the public, California translated these recommendations into a revised PSM standard. It requires greater attention by refinery managers on strategies to anticipate, analyze and prevent process incidents. The focus of the PSM standard shifted from requiring industrial practices that control risks to practices that substantially reduce risks or prevent risks from arising in the first place. To ensure effectiveness and enforceability, the revision improves worker participation in all PSM elements, with worker representatives selected by the workforce. It includes several measures to improve transparency and accountability in the process safety decisions made by refinery

managers. While the regulation is intended to protect refinery workers and the neighboring communities, it will also help ensure the stability and operational integrity of this important industrial sector.

Rather than relying on a rule-based set of requirements, the California revision expands upon and clarifies regulatory expectations in order to ensure that the performance-based rule is effective in practice. This approach is appropriate in a refinery setting, where thousands of potential risks must be identified, evaluated, prioritized and mitigated by applying expert judgement and professional engineering and management practices. The PSM revision acknowledges that judgement is vastly improved by involving the expertise of workers in all phases of process safety decision-making. This performance-based approach is expected to lead to continuing improvement, investment and innovation in process safety performance in refineries.

Development of L&I PSM Adopted Rules

In 2015, L&I established a Refinery PSM Advisory Committee to build cooperative relationship among refinery industry, labor and L&I to achieve PSM safety objectives. Additional objectives included reviewing the complete list of CSB recommendations, PSM improvement efforts from OSHA and California, and industry best practices to identify opportunities to further reduce or eliminate hazards associated with the catastrophic release of highly hazardous chemicals. The Refinery PSM Advisory Committee included business members from all five refineries in Washington State (BP Cheery Point, Shell (now Holly Frontier), US Oil & Refining Company (now Par Pacific), Tesoro (now Marathon Oil) and the Western States Petroleum Association and labor members from the United Steelworkers Local 12-591, AFL-CIO, the International Union of Operating Engineers, and the Washington State Building and Trades Council. Other participants at meetings included representatives from: L&I Boiler Program, the BlueGreen Alliance, the Chemical Safety Board, contractors who work at refineries, and other various interested parties.

On August 22, 2017, L&I files the Preproposal Statement of Inquiry (CR 101) to begin the formal rulemaking process to create PSM requirements specific to refineries. Incidents in the

refinery sector demonstrate that improvements in PSM continue to be needed, as evidenced in the 2014 CSB report, which concluded that there is "a considerable problem with significant and deadly incidents at petroleum refineries over the last decade." L&I considered the history of catastrophic events at refineries, CSB recommendations, information from OSHA, information from California's interagency workgroup and rule development efforts. Also, in Washington State petroleum refineries, WISHA violation trends have continued to increase during the time period of 2001-2018 stemming from incidents, referrals, and complaints indicative of an aging industry infrastructure leading to more unintentional releases and worker complaints of safety concerns. The most common deficiencies, by far, have been found in the operation, management, and maintenance of processing equipment. This aging infrastructure matters in regards to worker safety and environmental safety because of the actual highly hazardous nature of the products, additives and byproducts handled in these systems. Any release left unabated could lead to a catastrophic release that may result in additional worker deaths, and could reach beyond the property boundaries of the facilities themselves.

In response to common hazards found in Washington State petroleum refineries during field inspections, the revised rule will emphasize equipment integrity, the role of employees in the facility's PSM program, a defined role of accountability within the organization, and detailed analyses that explore incident scenarios and the facility's safety culture.

L&I worked with the business and labor stakeholders to develop the adopted rule language. The adopted rule largely aligns with California's rule, which is the most protective in the nation.

1.2.2 The adopted Process Safety Management Rule

The purpose of the adopted process safety management rule (chapter 296-67 WAC Part B) is to prevent catastrophic incidents, and to ensure the safety of employees while on the job at petroleum refineries.

The current PSM rule is identical to the federal standard issued by OSHA. The 14 elements found in the rule have been adequate for PSM-covered employers with simpler processes than those found in petroleum refineries. However, it has been increasingly apparent that the current rule doesn't meet the need for worker safety and health within a facility that has highly complex processes. For example, the current section directed at employee participation provides for a basic sharing of information between the employer and facility workers. However, employees haven't been included in part of a productive analysis. Process hazard analyses are an important part of evaluating a process and anticipating hazards. However, the analysis only focuses on single failure conditions rather than on combinations of possible events leading to failures. The current section for operating procedures is straightforward in terms of the minimum requirements for executing a complex task, but do not include human factors and the role that process operators play. The training section of the rule is reflective of training required in other rules. However, this section has also been found to fall short of the minimum requirements for a complex industry.

Contractor safety is currently a basic understanding between the refinery employer and the contractor employer. However, there hasn't been a consistent level of training for contractors, which has led to incidents in a facility. Pre startup safety reviews currently provide basic guidance, but no specific roles and responsibilities for those personnel performing the PSSR. The mechanical integrity element is arguably one of the most critical sections of the current rule. In the last 30 years, equipment has been aging further, inspection and testing practices have changed, and the section doesn't provide for critical worker roles and responsibilities. The current language falls short of the detailed analyses that can result in a safer infrastructure. Similarly, the incident investigation section is straightforward in terms of goal setting; but, over the years, investigating incidents has failed to fully reach the intent of the current rule. The emergency planning and response section currently references WACs that surround hazardous material releases; but there is little guidance with respect to how the employer will address specific types of releases and roles and responsibilities of all team members. Compliance audit requirements do not currently provide for sharing audit reports or recommendation feedback.

Finally, the trade secret section is reflective of other rules wherein the employer must provide information relating to worker safety and health.

In 2018, California's division of occupational safety and health (Cal/OSHA) implemented their PSM regulations for refineries. L&I worked diligently to ensure the Washington adopted rule aligned with the Cal/OSHA language as much as possible. As four of the petroleum refineries that operate in both California also operate in Washington, it was a priority to implement similar rules. Additionally, employees and contractors frequently work at petroleum refineries in both states, meaning that having similar regulations will be safer. There are only a few areas where L&I language differs from that of Cal/OSHA, and is appropriately more prescriptive to fit with how petroleum refineries operate in Washington.

One area where Washington language differs from Cal/OSHA is the use of the term *collaboration*, versus the use of the term *participation* throughout the rule. There is no increase in requirements by using a different term, since the tasks in the Cal/OSHA rule that require employee "participation" are also in our rule language. Employees will be doing the same tasks that are required by the Cal/OSHA rule, but the expectation is that Washington state employees will be actively engaged in the process with management. It was decided that the term "participation" didn't fully capture the active exchange taking place between employees and management like the term "collaboration" does. Another area where Washington language differs from Cal/OSHA is in mechanical integrity where the employer must take the necessary means to ensure that temporary repairs on process equipment do not fail and allow the safe operation of that equipment until a permanent repair is made.

The adopted rule has many new sections specific to addressing hazards found at petroleum refineries to help ensure employers are able to prevent incidents from occurring. In WAC 296-67-315, Employee Collaboration, employers are required to develop, implement and maintain a written plan that effectively provides for employee collaboration across all PSM elements including, but not limited to, process hazard analyses, damage mechanism reviews, process safety culture assessments, and incident investigations.

Another section that is vital to preventing incidents from occurring is WAC 296-67-347, Damage Mechanism Review. Employers must complete a damage mechanism review (DMR) for each existing and new process for which a damage mechanism exists, and every five years, employers are required to revalidate a DMR.

WAC 296-67-375, Process Safety Culture Assessment, requires employers to develop, implement, and maintain an effective process safety culture assessment (PSCA) program. At a minimum, the PSCA must include an evaluation of the effectiveness of many elements of process safety leadership including, but not limited to: the employer's hazard reporting program; response to reports of hazards; procedures to ensure that incentive programs do not discourage reporting of hazards; employee collaboration practices; and safe work practices. Every five years, an employer must perform an effective PSCA, and the team developing the PSCA must include at least one member knowledgeable in refinery operations, and at least one employee representative.

1.3 Description of Rule Amendments[2]

The adopted rule creates a new part—chapter 296-67 WAC Part B—that applies specifically to petroleum refineries. Part B replicates many of the sections from the current PSM rule, but also expands the application of the PSM standards, adds new sections, and creates additional requirements in certain existing elements.

WAC 296-67-300: Purpose and Scope.

Establishes that WAC 296-67-300 through WAC 296-67-387 create Part B of chapter 296-67 WAC. That Part B applies to processes within petroleum refineries. This new provision supersedes chapter 296-67 WAC, Part A, with respect to petroleum refineries.

[2] These descriptions come from cost explanatory document generated for the refinery survey and do not represent all changes identified as significant under the APA.

In addition, there is a list of specific chemicals and the quantity (pounds) at which they must be covered by this rule in a table in Appendix A of the current rule. The adopted rule eliminates this appendix so any hazardous chemical or material must now be included in a process.

WAC 296-67-311: Process Safety Management Program

This new section requires that employer must:

- Designate the refinery manager as the person with authority and responsibility for compliance with Part B of chapter 296-67 WAC,
- Develop, implement, and maintain an effective written process safety management (PSM) program, which must be reviewed and updated at least once every three years,
- Develop, implement, and maintain an organizational chart that identifies management positions responsible for implementing the PSM Program elements required by Part B of chapter 296-67 WAC, and
- Develop, implement, and maintain an effective program to track, document, and assess leading and lagging factors and process safety performance indicators.

WAC 296-67-315: Employee Collaboration.

Refineries are currently required to have a written plan for employee participation. The adopted rule represents an expansion of this requirement in the following areas:

- Employers will need to revise the written plan to provide for employee collaboration in PSM Program development and implementation planning, as well as to provide effective collaboration by affected operating and maintenance employees, throughout all phases, in performing: Process Hazard Analyses (PHAs), Damage Mechanism Reviews (DMRs), Hierarchy of Hazard Controls Analyses (HCAs), Management of Change Assessments (MOCs), Management of Organizational Change Assessments (MOOCs), Process Safety Culture Assessments (PSCAs), Root Cause Analyses (RCAs), developing and

maintaining Process Safety Information (PSI), and performing Pre-Startup Safety Reviews (PSSRs).

- Additionally, the employer will have to develop procedures for a Stop Work Authority (SWA), and develop and implement a corresponding training program.

WAC 296-67-319: Process Safety Information.

Process safety information (PSI) is an existing section, but the adopted rule includes new requirements and expanded application to previously uncovered processes.

- The expansion in application will require that PSI be generated or revised for newly covered processes, while the expansion in requirements will increase the cost of developing PSI for new (or newly covered) processes. Refiners must develop and maintain PSI prior to conducting PHAs, SPAs, HCAs, or DMRs.

- Under the adopted rule, PSI must include results of previous DMRs and damage mechanism data. Process equipment information should include design limits and operating limits and electrical supply and distribution systems.

- Under the adopted rule, PSI must include results of previous DMRs and damage mechanism data. Process equipment information should include design limits and operating limits and electrical supply and distribution systems.

- Employers are required to document that any new and existing process equipment complies with recognized and generally accepted good engineering practices (RAGAGEP).

WAC 296-67-323(1): Process Hazard Analysis

Process Hazard Analyses (PHAs) are the centerpiece of a PSM program, and they are required for all covered processes under the current rule. Under the adopted rule, PHAs will be required for the processes not currently covered. The PHA must address previous publicly documented process safety incidents in the petroleum refinery and petrochemical industry sectors that are

relevant to the process, DMR reports that are applicable to the process, and HCA reports that are applicable to the process, in addition to the components that are currently required.

WAC 296-67-323(2): Safeguard Protection Analysis

Safeguard Protection Analysis (SPA) is a new subsection of the Hazard Analysis element of PSM. A SPA must be performed for each scenario in the PHA that identifies the potential for a process safety incident, and must utilize a quantitative or semi-quantitative method such as Layer of Protection Analysis (LOPA). The SPA must be performed by at least one qualified individual with expertise in the specific SPA methodology being used. Employers must complete all SPAs, as part of the PHA or a standalone analysis, within six months of the completion or revalidation of the PHA.

WAC 296-67-323(3): Hierarchy of Hazard Controls Analysis

Hierarchy of Hazard Controls Analyses (HCAs) are among the most important additions to the PSM rule. Under the adopted rule, HCAs are required as stand-alone analyses for all existing processes, and are required on an ongoing basis: 1) for recommendations from a PHA; 2) for recommendations from an incident investigation; 3) as part of a Management of Change (MOC) analysis for 'major changes'; and 4) as part of the design and review of new processes, process units, facilities, and equipment. In addition, HCAs must be performed in a timely manner, and each analysis must be revalidated at least every five years.

WAC 296-67-327: Operating Procedures

The adopted operating procedures section expands the existing requirements. Significant additions under the adopted rule include:

- Adding procedures for start-up after planned or unplanned shutdowns and any other operating condition not described in this section,
- Incorporating human factors considerations,
- Including emergency procedures in the operating procedures for each process, and

- Developing safe work practices for dealing with releases of hazardous chemicals and materials.

WAC 296-67-331: Training

Under the current rule, employees involved in operating a process must be trained in an overview of the process, in operating procedures, and on safety considerations applicable to the employees' tasks. Under the adopted rule:

- Maintenance employees and contractors performing work on a covered process must be trained in an overview of the process and in the hazards and safe work practices related to the process.
- Maintenance employees must receive refresher training every three years resulting in additional ongoing costs.
- The employer must develop and implement a written program that identifies requirements for a 'qualified' employee designation and develop testing procedures for verifying competency.
- The employer must implement a written training program for affected employees on the adopted PSM elements and train them for collaboration in the various PSM elements.

WAC 296-67-335: Contractors

A few small changes were adopted in this section including that a contractor must ensure it has informed each of its employees of applicable refinery safety rules and the refinery employer must ensure and document that the requirements of this section are performed and completed by the contractor.

WAC 296-67-339: Pre-startup Safety Review

Pre-Startup Safety Reviews (PSSRs) are required under the current rule. But the adopted rule expands the topics that must be covered in PSSRs and applies to all processes.

Significant changes include that:

- The employer must perform a PSSR for partial or unplanned shutdowns and for all turnaround work performed on a process.
- The PSSR must confirm that process equipment has been maintained, prepared for start-up, and is operable in accordance with design specifications;
- For new processes, a PHA, HCA, DMR, and SPA have each been performed, as applicable, and recommendations have been implemented or resolved before start up.
- The employer must involve affected operating and maintenance employees in the PSSR who are qualified in the operations and engineering of the process being started, and provide for employee collaboration.

WAC 296-67-343: Mechanical Integrity

Mechanical integrity is a current requirement, but the adopted rule expands the section to include the following changes:

- Refineries must develop MI procedures for previously uncovered processes.
- Refineries must establish a process for evaluating new or updated codes and standards and implementing changes as appropriate to ensure safe operation.
- If the employer installs new process equipment or has existing process equipment for which no RAGAGEP exists, the employer must document and ensure that this equipment is designed, constructed, installed, maintained, inspected, tested and operated in a safe manner.
- When an equipment deficiency or failure mechanism is identified, substantially similar equipment in similar service must be evaluated for the same deficiency or failure mechanism.

WAC 296-67-347: Damage Mechanism Review

Damage Mechanism Reviews (DMRs) are a new requirement of the adopted rule. The major requirements in this section include:

- DMRs must be conducted for all processes for which a damage mechanism exists.
- All required DMR must be completed within five years of effective date of the adopted rule and revalidated at least once every five years, and DMR reports must be retained for the life of the process.
- DMRs must be performed by a team with expertise in engineering, equipment and pipe inspection, damage and failure mechanisms, and the operation of the process or processes under review.

WAC 296-67-351: Hot Work

Hot Work requirements are a section of the current rule, but the adopted rule includes additional requirements that refiners must revise written procedures for hot work and develop a system to retain permits.

WAC 296-67-355: Management of Change

Management of Change reviews (MOCs) are required under the current rule; but, the adopted rule includes additional requirements and will apply to additional processes under the expanded application of part B. Among the expanded requirements are:

- Potential safety impacts of the change must be addressed and documented;
- Modifications of maintenance procedures, or development of new operating or maintenance procedures must be addressed and documented; and,
- Prior to implementing a major change, a DMR must be reviewed and HCA must be conducted and reviewed.

WAC 296-67-359: Management of Organizational Change

Management of Organizational Changes (MOOCs) are a new requirement of the adopted rule. Under this section, the employer must develop, implement and maintain effective written procedures to manage organizational changes, and must designate a team to perform a written MOOC assessment. Also, the refinery manager or designee must certify, based on information and belief formed after reasonable inquiry, that the MOOC assessment is accurate and that the adopted organizational change meets the requirements of this section.

WAC 296-67-363: Incident Investigation – Root Cause Analysis

Incident investigation is an existing provision that includes several significant new requirements and a modified application. Under the current rule, investigations must be conducted for each incident which resulted in, or could reasonably have resulted in a catastrophic release of highly hazardous chemical in the workplace. Under the adopted rule, investigations must be conducted for "process safety incidents". Additionally:

- Refineries will need to develop written procedures for incident investigations that include a method for conducting root cause analysis (RCA).
- The incident investigation team must implement the employer's root cause analysis method to determine the initiating and underlying causes of the incident, develop recommendations to address the findings of the root cause analysis, and prepare a written investigation report within four months of the incident.

WAC 296-67-367: Emergency Planning and Response

Emergency planning and response are required under the current rule. The adopted rule includes additional requirements that the written plan must specify how an emergency response will be executed if it exceeds the capability of the employer's internal emergency response team. The employer must document any agreement with external emergency response organizations expected to assist in an emergency including schedules for planned drills, and provide for employee collaboration.

WAC 296-67-371: Compliance Audits

Compliance audits are required under the current rule, but the adopted rule includes additional requirements and will apply to additional processes under the expanded application of part B.

Specifically, the adopted rule requires the employer to consult with qualified process operators and provide a written response to employee or employee representative comments regarding the report.

WAC 296-67-375: Process Safety Culture Assessment

Process Safety Culture Assessment **(**PSCA) is a new section in the adopted rule. The rule requires that within 18 months of the effective date, the employer must develop a process safety culture program, conduct its first PSCA, and produce a written report that includes methods, findings, and recommendations for corrective actions. Additionally, the employer must develop and implement employee training for PSCA, implement corrective action plans, and develop interim reports within three years following the PSCA report.

WAC 296-67-379: Human Factors

The Human Factors (HF) program is new and requires the employer to implement a written HF program, identify factors, and develop methods of assessment. The program must be in place within 18 months of the effective date of the rule, and the employer must train employees on the HF program. Within five years of the effective date of the rule, the employ must assess HF in operating and maintenance procedures and revise them to incorporate HF considerations**.**

WAC 296-67-383: Corrective Action Program

The adopted rule requires that the employer develop, implement, and maintain a corrective action program (CAP) to review and consider recommendations of PHAs, SPAs, DMRs, HCAs, RCAs, and compliance audits**.** The employer must also develop and document corrective actions to implement each accepted recommendation. Additionally, the employer must track and document the completion of each corrective action.

WAC 296-67-387: Trade Secrets

The only proposed change in this section is to delete subsection (3) in WAC 296-67-061 in the current rule that states employees and their designated representatives shall have access to trade secret information contained within the PHA and other documents required to be developed by this standard.

1.4 Legal Requirements

In accordance with RCW 34.05.328, this cost-benefit analysis determines that the probable benefits of the rule are greater than its probable costs, taking into account both the qualitative and quantitative benefits and costs, and the specific directives of the rule being implemented.

1.4.1 Rulemaking Requirements & Administrative Procedures Act

Under the Administrative Procedures Act, RCW 34.05.328, L&I must satisfy specific legal criteria before adopting regulations.

The sole purpose of the Administrative Procedures Act is to allow regulations to be adopted or amended. Before a "significant legislative rule" is able to be adopted, L&I is required by the Administrative Procedures Act (RCW 34.05.328(1)) to:

(a) Clearly state in detail the general goals and specific objectives of the statute that the rule implements;
(b) Determine that the rule is needed to achieve the general goals and specific objectives stated under (a) of this subsection, and analyze alternatives to rule making and the consequences of not adopting the rule;
(c) Provide notification in the notice of adopted rulemaking under RCW 34.05.320 available. The preliminary cost-benefit analysis must fulfill the requirements of the cost-benefit analysis under (d) of this subsection. If the agency files a supplemental notice under RCW 34.05.340, the supplemental notice must include notification that a revised preliminary cost-benefit analysis is available. A final cost-benefit analysis must be available when the rule is adopted under RCW 34.05.360;

(d) Determine that the probable benefits of the rule are greater than its probable costs, taking into account both the qualitative and quantitative benefits and costs and the specific directives of the statute being implemented;

(e) Determine, after considering alternative versions of the rule and the analysis required under (b), (c), and (d) of this subsection, that the rule being adopted is the least burdensome alternative for those required to comply with it that will achieve the general goals and specific objectives stated under (a) of this subsection;

(f) Determine that the rule does not require those to whom it applies to take an action that violates requirements of another federal or state law;

(g) Determine that the rule does not impose more stringent performance requirements on private entities than on public entities unless required to do so by federal or state law;

(h) Determine if the rule differs from any federal regulation or statute applicable to the same activity or subject matter and, if so, determine that the difference is justified by the following:

(i) A state statute that explicitly allows the agency to differ from federal standards; or

(ii) Substantial evidence that the difference is necessary to achieve the general goals and specific objectives stated under (a) of this subsection; and

(iii) Coordinate the rule, to the maximum extent practicable, with other federal, state, and local laws applicable to the same activity or subject matter.

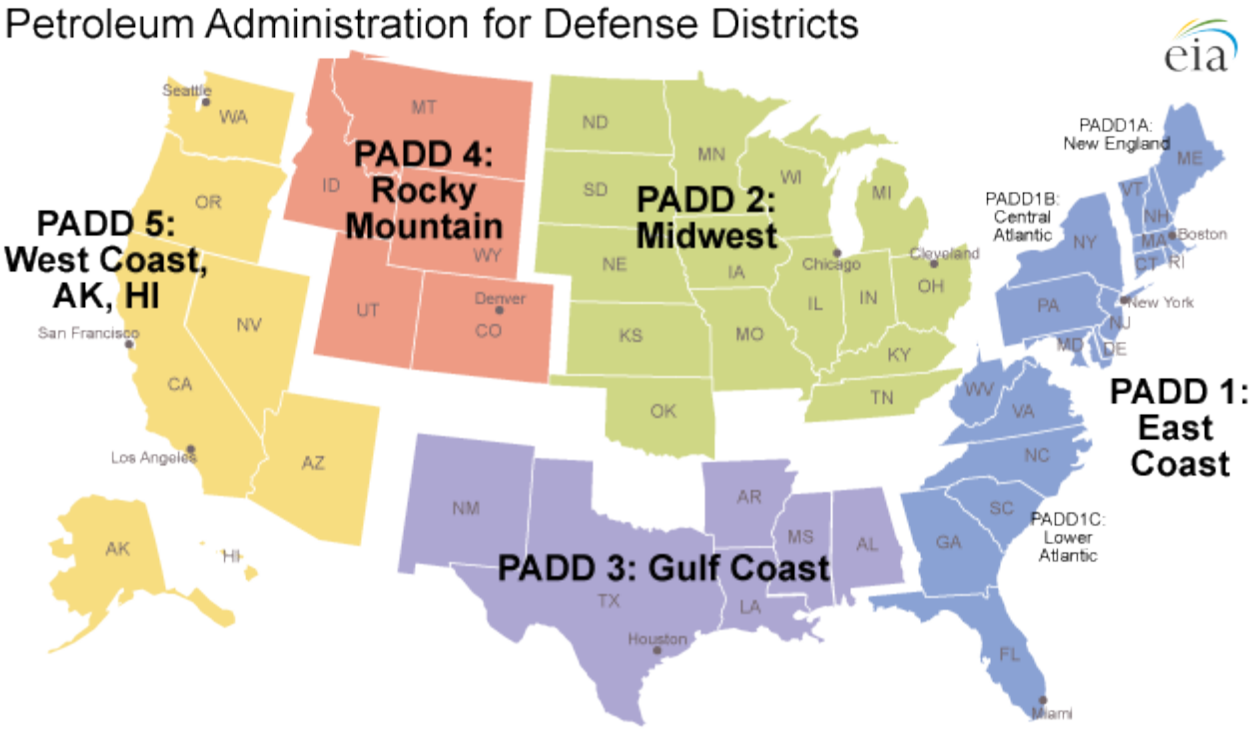
CHAPTER 2: PROFILE OF AFFECTED BUSINESSES AND WORKERS

2.1 Brief Description of Oil and Gas Industries in Washington

Washington State is a part of the West Coast transportation fuels region (PADD 5), which also includes: California, Arizona, Nevada, Oregon, Alaska, and Hawaii. Like other states in the PADD 5 region, Washington is isolated from the petroleum distribution systems of other regions; as a result, the state is more dependent on its in-state refining capacity than are states in other

fuel regions.[3] Isolation makes PADD 5 fuel markets susceptible to significant price volatility when refinery production is disrupted.

Figure 2.1: PADD Map[4]



In 2019, Washington State consumed 150.1 million barrels of finished petroleum products, including 70.0 million barrels (2.9 billion gallons) of motor gasoline, 28.4 million barrels (1.2 billion gallons) of distillate fuel oil, and 19.0 million barrels (798.0 million gallons) of jet fuel, accounting for 2% of national consumption of petroleum products.[5] By comparison, it produced 108.0 million barrels of motor gasoline, 57.3 million barrels of diesel fuel, and 35.4 million barrels of jet fuel, indicating that Washington's refining capacity substantially exceeds local demand. Of the finished product produced in Washington, only 46.1% of motor fuel (50 million barrels), 56.1% of diesel fuel (32.1 million barrels), and 73.2% of jet fuel (25.9 million barrels)

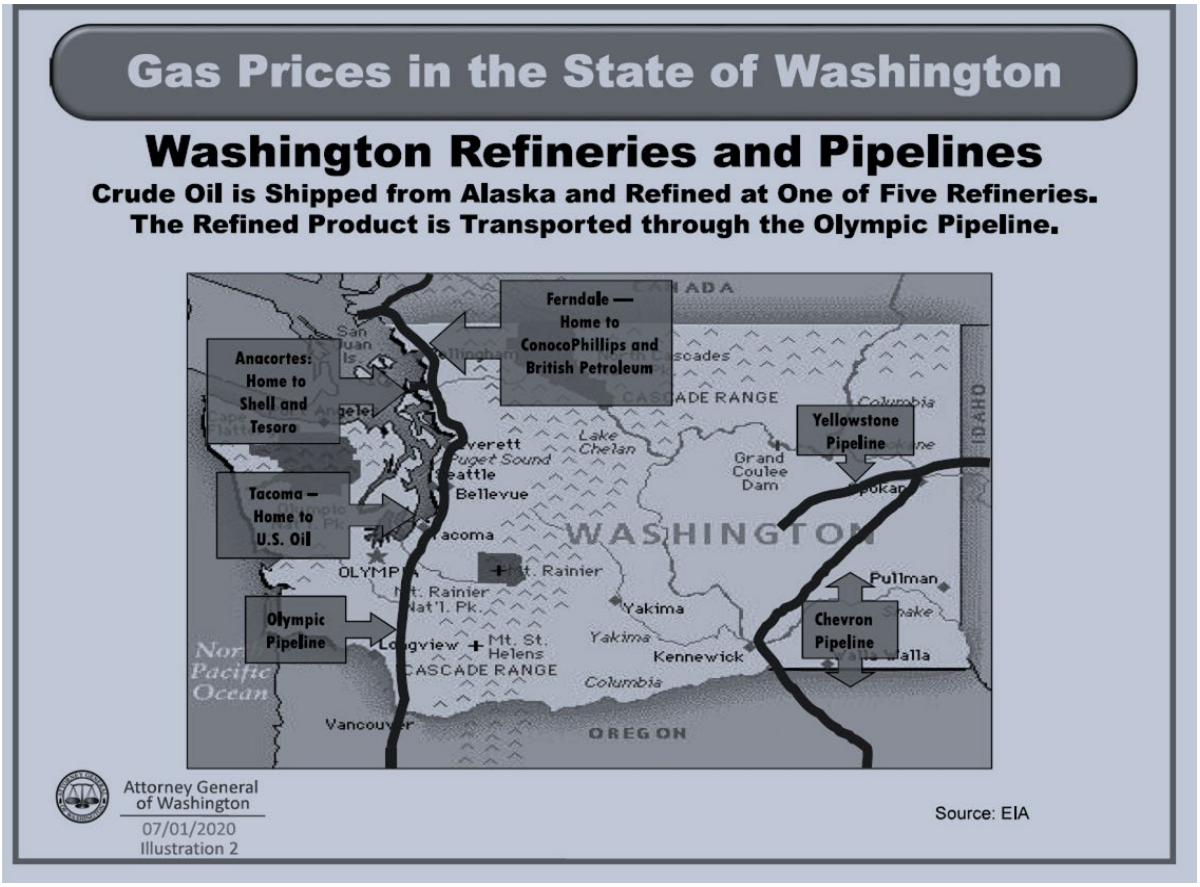
[3] Washington Research Council (WRC), 2021. The Economic Contribution of Washington State's Petroleum Refining Industry in 2019.
[4] Retrieved from EIA website (https://www.eia.gov/todayinenergy/detail.php?id=4890).
[5] EIA, 2021, U.S. Energy Information Agency, State Energy Data System (SEDs), "State Energy Consumption Estimates 1960 Through 2019."

were consumed within the state. The remainder was exported to other U.S. states such as Oregon and California, and also to other countries.[6]

Despite having excess capacity to meet its own transportation fuel needs, significant quantities of finished transportation fuels are imported to Washington from other states. Patterns of fuel distribution in Washington differ between the Western Washington and Eastern Washington regions. All five refineries are located in Western Washington, and they are connected to the Western Washington and Western Oregon fuel markets by the Olympic Pipeline (see Figure 2.2). There are no finished fuel pipelines connecting Washington refineries to Eastern Washington fuel markets; instead, Eastern Washington receives fuel supplies by truck and tanker transport via the Columbia River. Eastern fuel markets also connect to refineries in other regions via the Yellowstone and Chevron pipelines and import significant quantities of finished product from outside the state.[7] Because the refineries export a significant amount of finished motor fuel, there is effectively excess capacity that can potentially be diverted to Washington markets in the event of disruption of one of the refineries. Further, Eastern Washington is less reliant on fuels produced in the state, due to its connection with refineries in other regions.

[6] WRC, 2021.
[7] Washington State Department of Commerce, 2013 "Petroleum Supply and Use in Washington State: An Overview of Recent Developments in the Petroleum Market," October 2013, www.commerce.wa.gov/wp-content/uploads/2016/04/Energy-Petroleum-Whitepaper-7-15-2013.pdf, Accessed January 21, 2020.

Figure 2.2: Washington Refineries and Pipelines



Despite this excess capacity, refinery incidents and the resultant disruptions to refinery operations can have large impacts on transportation fuel prices. Fuel prices became so elevated in the West Coast region following the 2012 BP Cherry Point refinery fire that U.S. Senator Maria Cantwell called for an investigation of refinery operators by the Federal Trade Commission (FTC). The BP outage coincided with a number of planned and unplanned partial shutdowns of refineries in the West Coast region that resulted in reduce fuel inventories. A report by Robert McCullough suggested that historically low inventories resulted in $0.68 per gallon price hike in the West Coast region.

2.2 Refining Processes & Process Units

A refinery is a plant where crude oil is converted into various finished petroleum products, mainly gasoline, diesel oil and jet fuel. Different refineries have different configurations in

processes and process units, but normally there are four broad categories of processes in a typical refinery: separation, conversion, finishing (or treating), and supporting.

Each refinery is unique and no two refineries are identical in terms of the presence of refining processes (process units). Based on an extensive literature review of the studies and reports of the petroleum refining industry and discussions with internal and external technical experts, L&I identifies some of the primary processes and supporting processes that are most commonly present in a typical U.S. refinery described in Table 2.1 below. This table is by no means an exhaustive list of all possible processes & process units that have existed in the refining industry, and at a refinery level, a particular process design is normally dependent on the raw feedstock characteristics it selects and the final products it sells. Therefore, the presence and arrangement of these processes vary among refineries and no refinery will possess all of these processes.[8]

Table 2.1: Most Commonly Present Processes in a Typical U.S. Refinery

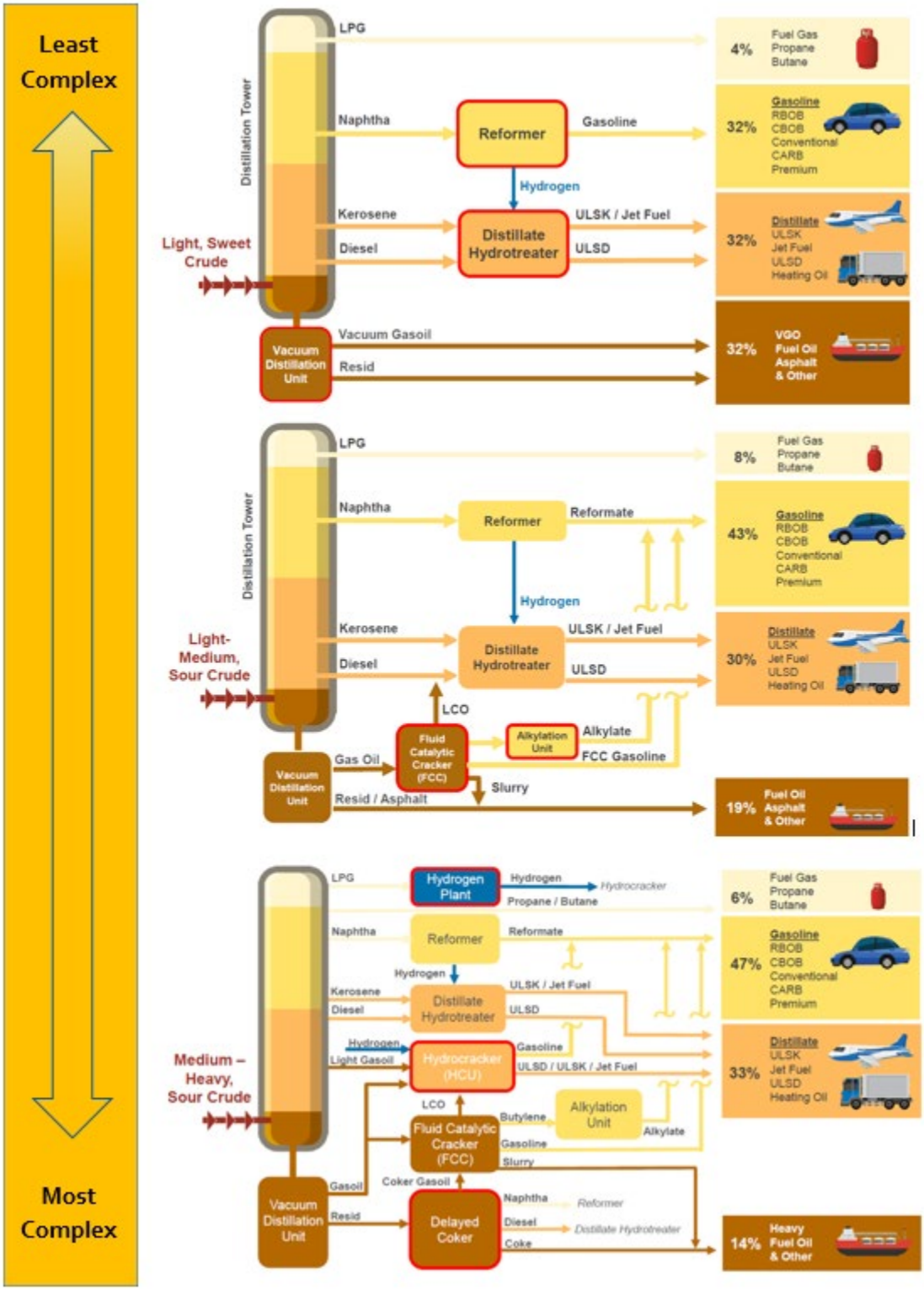
Type of Processes	Process Group	Process Name
Major	Separation	Atmospheric Distillation (ADU)
Major	Separation	Vacuum Distillation (VDU)
Major	Conversion	Fluid Catalytic Cracking (FCC)
Major	Conversion	Catalytic Reforming
Major	Conversion	Delayed Coking
Major	Conversion	Hydrocracking
Major	Conversion	Alkylation
Major	Conversion	Isomerization
Major	Finishing	Hydrotreating
Supporting	Supporting	Desalting
Supporting	Supporting	Blending
Supporting	Supporting	Wastewater Treating

[8] For example, the polymerization process was used extensively before World War II, but it has been replaced to a large extent by the alkylation process and is used very rarely in refineries today. The visbreaking process, one of the cracking methods, is another example which was developed in late 1930's but has been less used in modern refineries.

Supporting	Supporting	Sulfur Recovery
Supporting	Supporting	Cooling Tower
Supporting	Supporting	Hydrogen Synthesis & Production
Supporting	Supporting	Cogeneration Facility

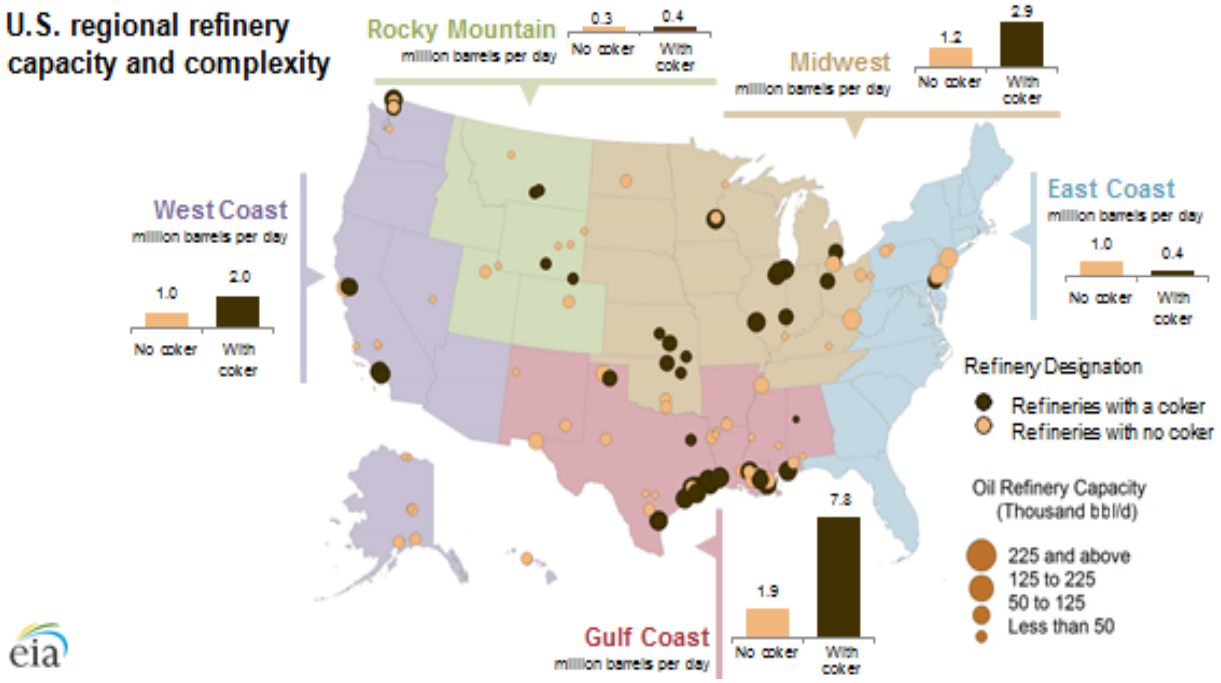
As described above, the refining operation is very complex and configuration varies uniquely by refinery. Figure 2.3 below depicts typical processes and units a refinery may possess based on its level of complexity. A low complexity refinery, often called hydroskimming or topping refinery, can only run light, sweet crude oil through its reformer and distillate hydrotreater units. A medium or moderate complex refinery is capable of running more sour crudes, mainly through its Fluid Catalytic Cracker (FCC) and Alkylation units, and achieving more high value products. The bottom chart describes a high complex refinery that possesses multiple complex units including the Delayed Coker which is used to run heavier and sourer crude oil. Units such as this enable refineries to achieve the highest yield of high-value light products.

Figure 2.3: Major refining processes, feedstock, and final products for refineries by complexity level (courtesy of Greg Bram, Valero, 2019)



Depending on the market demands, quality of crude oil inputs, and sources of crude supply, refinery configuration varies greatly across regions in U.S. For example, 81% of total capacity in Gulf Coast region is from the facilities with a coking unit, which can upgrade heavy crude oil into higher-valued lighter products, such as distillate and gasoline. By contrast, only 29% of crude oil is processed at the refineries with a coking unit in the East Coast region. In the West Coast region which includes Washington State, the refineries with a Coker account for 2/3 of total regional capacity.

Figure 2.4: Refineries with or without Coking Units[9]



On the final product end, U.S. refineries on average produce about 19-20 gallons of motor gasoline, 11-13 gallons of diesel fuel, and three to four gallons of jet fuel from every barrel of crude oil (42 gallons) they process.[10] Several other products are also produced including petroleum coke, still gas, hydrocarbon gas liquids, asphalt and road oil, lubricants, and petrochemical feedstock. With regard to the share of final products, gasoline accounts for the

[9] Retrieved from EIA website (https://www.eia.gov/todayinenergy/detail.php?id=19591).
[10] EIA: Frequently Asked Questions (last updated: April 19, 2022).

largest share, or about a half of total petroleum products, followed by diesel and jet fuel, which account for 27% and 6% respectively.[11]

Table 2.2: Petroleum Products and Their Shares –U.S. Refineries

Product	Share of Total Output
Finished motor gasoline	50%
Distillate fuel oil	27%
Kerosene-type jet fuel	6%
Petroleum coke	4%
Still gas	3%
Hydrocarbon gas liquids	3%
Asphalt and road oil	2%
All others	5%

2.3 Washington Refineries

Washington is a major crude oil refining center with the fifth-largest oil refining capacity in U.S. Washington's refineries receive crude oil supplies by pipeline from Canada, by ship and by rail primarily from North Dakota, and Alaska. There are 5 refineries that are currently operating in Washington State: Cherry Point refinery owned by BP, Puget Sound refinery owned by HollyFrontier,[12] Anacortes refinery owned by Marathon Petroleum,[13] Ferndale refinery owned by Phillips 66, and Tacoma refinery owned by Par Pacific.[14] According to the January 2021 refinery capacity and product data from EIA, the BP Cherry Point refinery is the largest in Washington State and the 4th largest on the West Coast, with a capacity of more than 240,000 barrels per calendar day, followed by the two refineries located in Anacortes. The Tacoma

[11] U.S. Energy Information Administration, Petroleum Supply Annual, August 2021.
[12] This refinery was known as Equilon until 2001 when Shell bought out Texaco's share of Equilon, making it the sole owner of both Equilon and the Puget Sound refineries. In 2021, Shell sold the Puget Sound Refinery to the HollyFrontier for $350 million.
[13] This refinery was known as the Tesoro Anacortes refinery prior to August 2017 and the Andeavor Anacortes refinery between August 2017 and October 2018.
[14] This refinery was owned by U.S. Oil & Refining Company prior to November 2018.

refinery is the smallest in the state with a capacity of approximately 40,000 barrels per day. Altogether, the 5 refineries process more than 650,000 barrels of crude oil per day. Four out of five Washington refineries began their operations between 1954 and 1958. The Cherry Point refinery is the newest one that began operating in 1971. It is also the last major oil refinery built in the United States.[15]

Table 2.3: Basic Information about Washington Refineries

Refineries in WA	Owner	Location	County	Capacity in bpcd	Operation Start Year[16]
Cherry Point Refinery	BP	Blaine	Whatcom	242,000	1971
Puget Sound Refinery	HollyFrontier	Anacortes	Skagit	145,000	1958
Anacortes Refinery	Marathon	Anacortes	Skagit	119,000	1955
Ferndale Refinery	Phillips 66	Ferndale	Whatcom	105,000	1954
Tacoma Refinery	Par Pacific	Tacoma	Pierce	40,700	1957

Based on this same EIA data, L&I is able to identify the primary process units that each Washington refinery currently possesses and the associated processing capacities. Table 2.4 summarizes the major process units and their capacities by each Washington refinery. All of the five refineries have at least an ADU and VDU for crude distillation, a Reformer for conversion process, and multiple Hydrotreater units to remove sulfur and other impurities from refinery streams before blending into a finished refined product or before being fed into another refinery process unit.[17]

[15] Wikipedia: Cherry Point Refinery.
[16] Data Source: Industrial Facilities Permits, Washington State Department of Ecology.
[17] The hydrotreaters can be further divided into Naphtha hydrotreater for reformer feeds, FCC gasoline hydrotreater, distillate hydrotreater for diesel fuel, and kerosene hydrotreater for jet fuel, etc.

Table 2.4: Primary Process Units and Their Capacities

Process Unit / Capacity (bpsd)	Cherry Point-BP	Puget Sound-HollyFrontier	Anacortes -Marathon	Ferndale-Phillips 66	Tacoma-Par Pacific
ADU	251,000	149,000	120,000	110,500	42,000
VDU	139,000	65,800	47,000	48,100	19,200
Reformer	65,000	21,700	28,500	18,500	6,800
Hydrocracker	65,000	-	-	-	-
Delay Coker	61,500	25,300	-	-	-
FCC	-	57,900	54,500	38,000	-
Alkylation	-	12,500	17,000	12,700	-
Isomerization	26,000	-	6,500	2,900	4,500
Hydrotreaters	180,800	130,500	101,000	91,300	18,900

It is worth noting that the key configuration difference in refineries lies in their conversion unit combinations (see Table below). Specifically, the largest Washington refinery, Cherry Point plant, has a Hydrocracking unit, a Catalytic Reforming unit, a Coking unit, and an Isomerization unit.[18] On the other hand, the two refineries in Anacortes and the refinery in Ferndale have a Reformer, a Fluid Catalytic Cracking (FCC) and an Alkylation unit but no Hydrocrackers. In addition, the Anacortes refinery owned by HollyFrontier also has a coking unit while the Anacortes - Marathon and the Ferndale refinery have Isomerization units. By contrast, the smallest and simplest refinery in Washington, the Par Pacific refinery in Tacoma only has a Reformer and an Isomerization to convert naphtha into a higher-value gasoline blend stock.

[18] This includes a $169 million Hydrocracker Improvement Project, a $55 million Cooling Water Infrastructure Project, and a $45 million Renewable Diesel Optimization project.

Table 2.5: Primary Conversion Units by Refinery

WA Refinery /Process Unit	Reforming	FCC	Alkylation	Isomerization	Coking	Hydro-cracking
Cherry Point -BP	X			X	X	X
Puget Sound - HollyFrontier	X	X	X		X	
Anacortes - Marathon	X	X	X	X		
Ferndale - Phillips 66	X	X	X	X		
Tacoma - Par Pacific	X			X		

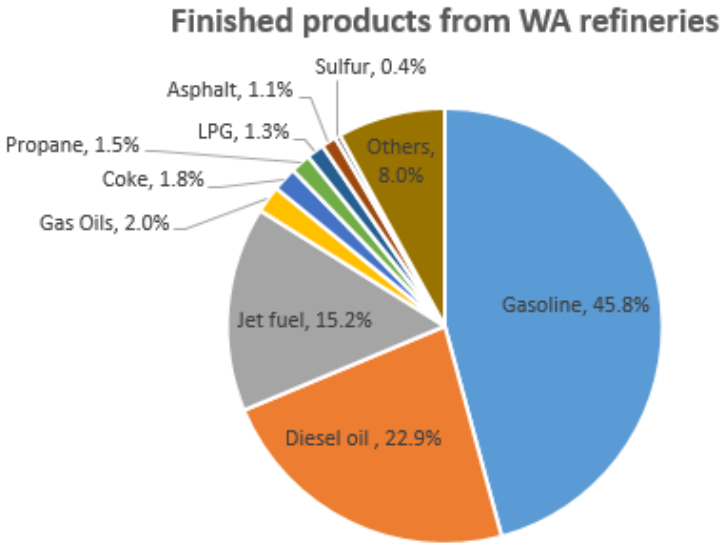
Washington refineries also have various supporting process units to meet the needs of refining operation and produce specific by-products. For example, the BP Cherry Point plant has a Sulfur Recovery Unit that can produce 284 tons of sulfur and a Hydrogen Production Unit capable of producing 186 million cubic feet of hydrogen every day.[19] The other refineries also have sulfur plants that can produce sulfur as a finished product.

With regard to the finished products from these refineries, gasoline accounts for more than 45% of the total. Diesel oil accounts for 23%, followed by 15% from jet fuel, other products include gas oil, asphalt, propane, coke, sulfur and LPG.[20]

[19] In 2021, BP also announced plans for a $269 million investment in three capital projects at this facility aimed at improving its efficiency, reducing its carbon dioxide (CO2) emissions and increasing its renewable diesel production capability.

[20] Data source: Washington Research Council, 2019.

Figure 2.5: Shares of Finished refinery products in Washington



2.4 Employee Profile

Refineries hire a wide variety of employees in engineering, construction, management and administrative duties. This includes refinery operators and assistants who are responsible for directing and controlling the continuous processes in refining, and maintaining detailed records of reading, test results and adjustments of the temperature, pressure, flow-rate and other critical parameters in various process units. It also includes pump operators and helpers who control, monitor and maintain the pumping system to keep the fluid products moving through the refinery. Other workers employed in the petroleum refining industry include chemical engineers and chemists who design and plan the layout of refining equipment and develop safety procedures, maintenance workers and installers who help repair, replace and clean the pipes, tanks, towers, and machines, as well as engineers of other kinds, supervisors, and managers. Below is the list of major occupations that are hired in refining industry in U.S.

Table 2.6: Employment shares and average salaries of major occupations in refineries[21]

Occupation	Share of employment	Average annual salary
Miscellaneous production workers	11.1%	$87,671
Chemical Engineers	7.12%	$122,101
Miscellaneous plant & system operators	7.08%	$88,326
First line supervisors of production & operating workers	5.87%	$102,188
Other managers	4.23%	$157,504
Inspectors, testers, sorters, samplers, & weighers	2.76%	$65,163
Electricians	2.59%	$83,968
Labors & freight, stock & material movers, hand	2.56%	$56,742
Accountants & auditors	2.22%	$105,887
Welding, soldering, & brazing workers	2.11%	$75,571
Industrial & refractory machinery mechanics	2.09%	$86,679
Production, planning & expediting clerks	2.05%	$126,521
Plumbers, pipefitters, and steamfitters	1.92%	$89,835
Geological & petroleum technicians & nuclear technicians	1.83%	$70,400
Driver/sales workers & truck drivers	1.74%	$74,971
General & operations managers	1.63%	$142,043
Computer occupations, all other	1.5%	$95,344
Chemists & materials scientists	1.49%	$129,823
Maintenance & repair workers, general	1.42%	$101,741
Machinists	1.4%	$72,896
Boilermakers	1.4%	$63,933
Other engineering technologists and technicians	1.27%	$96,318
Occupational health and safety specialists and technicians	0.95%	$105,681
Petroleum, mining & geological engineers	1.14%	$190,825
Chemical technicians	0.82%	$71,928

[21] Data source: The Census Bureau ACS PUMS 1-year estimate for 2019.

There are more than 2,200 workers employed in the petroleum refining industry in Washington State. Petroleum Pump System Operators, Refinery Operators, and Gaugers is the largest occupation, accounting for 28.7% of the total workforce. Chemical Plant & System Operators is the second largest at 6.6%, followed by First-Line Supervisors of Production & Operating Workers and Maintenance & Repair Workers, which accounts for 4.8% and 4.6% respectively. Table 2.7 below shows the employment shares and median hourly wage of the largest 20 occupations in petroleum industry in Washington.

Table 2.7: Top 20 Occupations in petroleum industry in Washington

SOC	Occupation	Share of employment[22]	Median wage[23]
51-8093	Petroleum Pump System Operators, Refinery Operators, and Gaugers	28.7%	$35.47
51-8091	Chemical Plant and System Operators	6.6%	$36.50
51-1011	First-Line Supervisors of Production and Operating Workers	4.8%	$33.42
49-9071	Maintenance and Repair Workers, General	4.6%	$22.84
49-9041	Industrial Machinery Mechanics	4.1%	$31.14
51-2090	Miscellaneous Assemblers and Fabricators	2.8%	$18.31
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	2.5%	$39.35
17-2041	Chemical Engineers	2.5%	$50.29
19-4031	Chemical Technicians	2.5%	$24.53
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	2.2%	$28.29
17-2171	Petroleum Engineers	2.1%	$62.38
11-3010	Administrative Services Managers	1.7%	$57.21
15-1232	Computer User Support Specialists	1.6%	$29.09
13-1199	Business Operations Specialists, All Other	1.5%	$39.44
17-2141	Mechanical Engineers	1.5%	$47.80
11-9041	Architectural and Engineering Managers	1.5%	$75.23
51-9023	Mixing and Blending Machine Setters, Operators, and Tenders	1.5%	$22.14
11-1021	General and Operations Managers	1.4%	$57.15

[22] Data source: 2020Q2 Occupation-Industry Matric Data from ESD, WA. The data includes the petroleum and coal product manufacturing industries (NAICS: 3241).
[23] Occupational employment and wage statistics, 2021, ESD, WA.

11-3051	Industrial Production Managers	1.4%	$59.28
49-9012	Control and Valve Installers and Repairers, Except Mechanical Door	1.2%	$40.19

Due to the significant difference in production capacity and complexity of the five Washington refineries, their employment sizes also vary greatly. For example, the largest Washington Refinery- BP Cherry Point, has almost 900 employees while the workforce in the smallest refinery in Tacoma is only about 190 workers. On average, each refinery in Washington employs about 451 workers.

Table 2.8: Workforce in Each Washington Refinery

WA Refinery	Number of Employees (excluding contractors)
Cherry Point -BP[24]	890
Puget Sound - HollyFrontier[25]	500
Anacortes - Marathon[26]	390
Ferndale - Phillips 66[27]	285
Tacoma - Par Pacific[28]	190
Average size of workforce	451

[24] BP Fact Sheets (https://www.bp.com/content/dam/bp/country-sites/en_us/united-states/home/documents/where-we-operate/states/bp%20in%20Washington.pdf)
[25] Shell Puget Sound Refinery (https://www.shell.us/about-us/projects-and-locations/puget-sound-refinery/about-shell-puget-sound-refinery.html)
[26] Marathon Anacortes Refinery Fact Sheet (https://www.marathonpetroleum.com/content/documents/fact_sheets/Anacortes_Refinery_Fact_Sheet.pdf)
[27] Data source: Washington State Department of Ecology Oil Refinery Permit for this refinery.
[28] Data source: Washington State Department of Ecology Oil Refinery Permit for this refinery.

CHAPTER 3: COSTS OF ADOPTED RULE

3.1 Baseline for This Analysis

The baseline for this analysis is all regulatory requirements that are currently applicable to the refining industry and the recommendations on safety practices from relevant national consensus standards. This includes all applicable rules from OSHA, EPA, and other federal agencies that regulate the refining industry, all existing requirements under chapter 296-67 WAC for refineries, and the safety practices recommended by national consensus standards such as those from National Fire Protection Association (NFPA) and American National Standards Institute (ANSI).

Table 3.1: Current PSM Requirements in OSHA and EPA Regulations

Rule Element	OSHA PSM 29 CFR (1992)	EPA CAA 112(r) 40 CFR RMP[29]
Risk Management program / System	N/A	68.15
Employee Participation	1910.119(c)	68.83
PSI	1910.119(d)	68.65
PHA	1910.119(e)	68.67
Operating Procedures	1910.119(f)	68.69
Training	1910.119(g)	68.71
Contractors	1910.119(h)	68.87
PSSR	1910.119(i)	68.77
Mechanical Integrity	1910.119(j)	68.73
Hot Work Permit	1910.119(k)	68.85
MOC	1910.119(l)	68.75
Incident Investigation	1910.119(m)	68.81
Emergency Planning and Response	1910.119(c)	68.83
Compliance Audits	1910.119(o)	68.79
Trade Secrets	1910.119(p)	N/A

[29] For Program 3 type businesses.

Per RCW 34.05.328 (5)(b), all the baseline requirements described above are exempt from this analysis, hence L&I will only analyze the adopted rule amendments that are above and beyond the baseline requirements. With regard to the state and federal requirements, the current Washington rule is essentially identical to the 1992 OSHA PSM rule, and Washington petroleum refineries must also comply with the EPA's RMP rule. L&I relies on published PSM materials and industrial knowledge from its internal experts to update baseline estimates to better reflect current refinery practices. Compliance costs for new and expanded requirements that are attributed to the adopted rule are derived based on responses to a survey administered to industry representatives, discussions with internal and external experts, as well as relevant information in published government reports such as the economic impact analyses of PSM regulations from OSHA and EPA.

3.2 Major Assumptions and Normalizations for This Analysis

3.2.1 Analysis Duration

L&I uses a 10-year analysis duration for the estimates based on the following considerations:

- The current state regulation on the petroleum refining industry mirrors the requirements from the OSHA PSM rule which was adopted 30 years ago. Given this history and the extent to which the rule has been amended in this proposal, L&I expects that this new rule, if adopted, will remain sufficiently effective for at least 10 years. The rule may need to be updated occasionally to address the changing technologies and other factors, but the majority of the key requirements in it will remain appropriate and adequate.
- OSHA and many other federal agencies as well as the industry have chosen a 10-year time frame for their impact analyses of major regulations. This includes OSHA's cost-benefit analysis for its current PSM rule in 1992 and adopted updates to PSM rule in 2013 and 2016, and EPA's various analyses on its refinery related regulations in different years.

- Many major requirements in this rule have a five-year completion or revalidation schedule, so a 10-year timeframe aligns with this schedule making the analysis easier to understand.

Based on this selection, if the compliance costs from a specific requirement only occur once, they will be annualized through the entire 10-year period. For the recurring or ongoing costs, they will not be affected by the choice of time frame for the analysis.

3.2.2 Estimates of Processes and Process Unit

Table 2.4 in Section 2.3 indicates that except the Tacoma refinery, each Washington refinery possesses seven major process units for its refining operation. There are also certain supporting processes that each facility needs including those listed in Table 2.1. The number of supporting processes in each plant is expected to vary among refineries. From the cost analysis perspective, L&I estimates there are four major supporting processes in Tacoma refinery and six in all other refineries. Thus, the total number of processes that will be analyzed in each of the process-based rule element is 13 for all refineries except for the Tacoma refinery, which has nine. This assumption is made based on the literature review of current refinery practices coupled with the consultation of L&I's subject matter experts.[30] It is worth noting that L&I does not expect that these are the only processes that exist in refineries. Rather, they are the major primary and supporting processes used to represent the "typical" refinery processes when analyzing the cost burden for each rule element in this report. The labor burdens for other processes are expected to be much smaller, hence their cost implications will not be treated equally to those outlined above. Rather, the costs associated with these other processes will be reflected in the upper-bound total cost as a rough estimate in Section 3.5.

With regard to the number of processes that are not currently covered by the existing federal or state PSM rules but will be covered under this adopted rule, L&I determined that all the primary

[30] This estimate was significantly higher than the average number of 4 processes per refinery reported from OSHA's PEL survey for its 1992 rule analysis (Kearney/Centaur, 1990).

processes listed in Table 2.1 are currently covered, while most supporting processes will likely be newly covered due to the expanded scope adopted in this rule.

Table 3.2: Primary Processes, Supporting Processes, and Newly Covered Processes

Refinery	Major primary processes	Major supporting processes	Newly covered processes
Cherry Point -BP	7	6	5
Puget Sound - HollyFrontier	7	6	5
Anacortes - Marathon	7	6	5
Ferndale - Phillips 66	7	6	5
Tacoma - Par Pacific	5	4	3

3.2.3 Unit Compliance Cost Differentiation by Refinery Complexity

The actual per-refinery cost for each rule element is likely to vary greatly among refineries across the industry depending on the number of processes, process complexity, and the number of employees, amongst other factors. The five refineries in Washington are very different in their production capacities and employment sizes as indicated in Table 2.3 and Table 2.8 respectively. For example, the Cherry Point refinery has 5.9 times processing capacity and 4.7 times workforce compared to the Tacoma refinery. The other three are also much bigger and have far more employees. A larger refinery also tends to have more process units than a smaller one, thus are more complex as a whole. Table 2.4 and Table 2.5 present the major process unit differences among these refineries.

Another way to compare each refinery is to look at its Nelson Complexity number, the most widely known complexity index in the industry. It assigns a complexity factor, the complexity of each major process unit a refinery owns as the grassroots construction cost relative to that of the atmospheric distillation unit (ADU) normalized on a capacity basis,[31] and aggregate each unit's

[31] The complexity factors assigned to each type of process unit range from 1 to 20. They are meant to roughly reflect the relative capital cost of the different units, but they are also assumed to correlate with relative operating

complexity factor to measure the complexity and sophistication of a refinery in a single number. While the compliance cost of each requirement analyzed in this report may not be perfectly aligned with the complexity level of each refinery measured by this index, it is expected that a more complex refinery will normally incur higher unit compliance costs than a less complex plant, and the Nelson complexity index is the best proxy available for this cost difference. As to the five refineries in Washington, their complexity scores range from 4.1 to 10. Using the medium sized refinery, Marathon-Anacortes, as the basis, the unit cost ratios for other refineries range from 0.48 for the smallest refinery to 1.18 for the largest.[32] For example, the labor burden of performing a PHA for each major process in the Tacoma refinery would be approximately 48% of the time for the Marathon refinery due to the complexity difference in these two facilities.

Table 3.3: Washington Refineries and Their Nelson Complexity Score

WA Refineries	Capacity Ratio	Nelson Complexity[33]	Normalized Cost Ratio by Nelson Score
Cherry Point -BP	2.03	10	1.18
Puget Sound - HollyFrontier	1.24	9.0	1.06
Anacortes - Marathon	1.00	8.5	1.00
Ferndale - Phillips 66	0.90	7.7	0.91
Tacoma - Par Pacific	0.34	4.1	0.48

3.2.4 Compliance Cost Reductions in Subsequent Years

Many elements in this PSM rule require updates and revalidations on a regular basis. For example, the PSM program must be reviewed and updated at least once every three years, and

costs and margin contribution. The complexity number provides a useful single measure for comparing multiple refineries with different configurations and normalizing operating costs.

[32] Some requirements are based on the employment size or other company-specific measure, and the costs for these requirements will be adjusted based on the actual differences in these metrics.

[33] Computed by the author based on the 2011 NCI factor and each refinery's 2021 capacity data except for the Cherry Point refinery, whose complexity score is provided in this article (https://www.nsenergybusiness.com/projects/cherry-point-refinery-upgrade/)

the written PHA must be updated and revalidated at least every five years. Given the similarity of the required contents and the increasing amount of information accumulated from each previous cycle, L&I assumes the cost of complying with a specific rule element will be reduced by 20% each time it needs to be updated or revalidated.[34] For example, if the initial development of the Process Safety Management program requires 2,000 hours in the first year for a refinery, it will require 20% less time to update this program the next time it is required to do so. The resulting labor cost for this requirement will be 1,600 hours in the fourth year, 1,280 hours in the seventh year, and so on. In other years when only maintenance is required, L&I assumes that about 33% of the initial labor burden is needed to perform the tasks, in line with the requirement that the overall PSM program must be reviewed and updated once every three years.[35]

3.2.5 Hourly Labor Cost

The refining industry employs a wide variety of workers in different capacities and the labor costs vary significantly by job. For example, the Geoscientists & Hydrologists were paid as much as $262,766, while Helpers-Production Workers in the refining industry were only paid $26,351 in 2019.[36]

While it is impossible to identify all types and numbers of workers involved in each job task, L&I adopted an average hourly rate of $100.41 as the unit labor cost for performing most of the tasks in this analysis that would require a high level of engineering knowledge and management skills. This rate is computed based on the average wage of the four levels of engineers,[37]

[34] This 20% reduction rate is much lower than what EPA adopted in its 1996 RMP rule analysis which used a reduction rate of 50% or 90% for its major risk management program elements.
[35] L&I has discussed with Cal/OSHA technical experts about these assumptions and think they are reasonable.
[36] Data source: DataUSA for Petroleum Refining (https://datausa.io/profile/naics/petroleum-refining)
[37] The hourly wages for various levels of engineers are estimated and adjusted based on AIChE 2019 Salary Survey and the total wage growth of 19.14% from 2019 to 2023.

weighted by their employment shares, in the refining industry as identified by OSHA.[38] The vast majority of engineers in refineries are Level III and Level IV engineers.[39]

Table 3.4: Median Wages and Employment Shares for Various Engineers in Refineries[40]

Labor Category	Description	Median Wage	Loaded wage	Percent of employment
Level VI Engineer	General Management, Responsibility for the Organization	$109.98	$164.96	2%
Level V Engineer	Manage a Major Department, Division, or Program	$97.26	$145.89	2%
Level IV Engineer	Directly Supervise a Project or Section, or TEAM	$74.46	$111.69	32%
Level III Engineer	No supervisory responsibility	$60.92	$91.37	64%

For other more routine work that does not require as much skills and knowledge and certain tasks like training of production and service workers, L&I assumes an average labor cost of $55.01 per hour. This unit hourly cost is the employment weighted average hourly rate for the top 20 occupations in 2021, excluding those engineers and managers, employed in Washington refineries (see Table 2.7). This average cost is also very close to what OSHA used in its 2013 and 2016 analyses ($52.01).

3.2.6 Composition of a Qualified Team for Key Requirements

The adopted rule describes what a team should consist of in order to successfully perform many critical tasks. For example, the rule requires PHAs to be performed by a qualified team with expertise in engineering and process operations and that must include at least one refinery

[38] OSHA (2016): Report of the Small Business Advocacy Review Panel on OSHA's Potential Revision to the PSM, Table B-15: Wage Rates for Petroleum Refineries and Gas Processors.
[39] Similarly to the EPA 1996 analysis for its RMP rule, L&I expects the refineries can comply with the rule elements analyzed in this report without hiring consultants.
[40] All wages are inflation adjusted to July, 2023.

operating employee and one member with expertise in specific PHA methodology. Similar requirements are adopted for SPAs, HCAs, DMRs, RCAs, and PSCAs. Based on several discussions with our internal experts, as well as the external technical experts from Cal/OSHA, L&I assumes a team performing PHAs & SPAs will need seven employees to be involved, while HCA will require a six-employee team. For DMR and RCA requirements, a three-employee team will be needed to fulfill each task.

In addition, the development and implementation of the overall PSM program, PSI, PSCA, and several other elements are closely related to the key requirements described above, so L&I also assumes it would take a three-person team to work together to complete these tasks. For the corrective action program setup, L&I assumes it will involve a team of five employees.

Table 3.5: Key Process-Based Elements and Team Composition

PSM Element	Team Composition	Team Size[41]
PHA &SPA	PHAs must be performed by a qualified team with expertise in engineering and process operations; must include at least one refinery operating employee and one member with expertise in specific PHA methodology. For SPAs, at least one qualified individual with expertise in the specific SPA methodology.	7 employees
HCA	Must be documented, performed, updated and revalidated by a team with expertise in engineering and process operations; must include one member knowledgeable in the HCA methodology and at least one operating employee involved in the process.	6 employees
DMR	Must be performed by a team with expertise in engineering, equipment and pipe inspection, damage & failure mechanisms, and the operation of the processes under review; must include one member knowledgeable in specific DMR methodology.	3 employees

[41] The team can be a mix of PSM manager(s), process and chemical engineer(s), operator(s), operations supervisor(s), and employee(s) with expertise in the specific methodology of the task.

RCA	Must be performed by an incident investigation team, which at a minimum consists of a person qualified in the process involved, a person qualified to perform the root cause analysis method, and a person qualified to oversee the investigation and analysis.	3 employees
PSM Program	Likely be performed by a team consisting of a PSM manager, a high level engineer, and a safety specialist.	3 employees
PSI	Likely be performed by a team with expertise in engineering, equipment, chemical and process operations.	3 employees
PSCA	Likely be implemented by a team consisting of an internal PSCA specialist, a PSM manager, and an operations employee.	3 employees
PSSR	Likely be performed by a team consisting of a process engineer, an operator, and a maintenance worker.	3 employees
Corrective Action Program	Likely be set up by a team consisting of a plant manager, a high-level engineer, a maintenance manager, an operations supervisor, and an employee representative	5 employees

3.2.7 Capital Costs Associated with Recommendations for Corrective Actions

The adopted rule created a new section for corrective actions stating that employers develop, implement, and maintain an effective written corrective action program to prioritize and implement accepted recommendations from PHAs, SPAs, DMRs, HCAs, Incident Investigations and compliance audits.

Certain corrective actions from these recommendations may lead to significant capital expenses for employers, but the cost impact of them will not be considered in this report mainly due to the following two reasons:

- Many of them are not attributable to this adopted rule. Instead, they are already explicitly or implicitly required under current applicable laws and rules. For example, a

recommendation to resolve the equipment deficiency and failure issues is the result of the current inspection and testing requirement under the mechanical integrity section. A recommendation to address certain process hazards can also be implied from the current provision that requires employers to implement inherent safety measures.

- The rule requires employers to conduct various types of analyses or reviews, but allows employers considerable latitude in making decisions regarding recommendations they may receive. Employers can reject a team's recommendation if it is based on an erroneous method, irrelevant to process safety, or infeasible. They can also change the recommendation if an alternative measure exists that would provide an equivalent order of inherent safety.

3.3 Methods and Data Sources

As mentioned above, the vast majority of compliance costs of the adopted rule are those associated with labor time of professional and technical staff on the expanded and new requirements. In order to estimate the labor burden of each rule element, L&I relies on a variety of sources including the cost inputs from the refining industry through a specially designed survey, the cost data from OSHA and EPA for similar requirements in their PSM rule analyses, and the comments and advice on the cost impacts of certain elements from L&I's internal technical experts and external subject matter experts.

The compliance cost survey was designed as a result of collaborative effort by L&I's internal staff in December 2019 to seek industry inputs. The survey was sent out to the industry in January 2020 and the responses were received in March 2020.[42] In order to avoid potential conflicts involving confidential data or other proprietary information from the refiners,[43]

[42] Additional details and clarifications were obtained in a follow-up meeting in April 2020 that included L&I personnel, WSPA, and industry representatives. Industry representatives indicated that the refineries may already be doing some of activities/analyses that are new requirements of the adopted rule; however, those activities are counted as representing new costs in the estimates they provided to L&I.

[43] WSPA claimed specifically that "given the small number of affected facilities and the fact that information submitted in response to the survey would generally be subject to disclosure under the Washington Public Records

L&I allowed the Western States Petroleum Association (WSPA) to provide aggregated estimates from the Washington refineries it represents.[44] The survey covers each major requirement adopted by the new rule. It also includes L&I's preliminary cost estimates for each required task and the overall projected costs for the average refinery and the industry as a whole.

The current DOSH PSM rule for Washington refineries is essentially identical to the Federal OSHA PSM rule and EPA's RMP standard which Washington petroleum refineries must already comply with. Therefore, L&I relies on published PSM materials from these agencies to develop the current PSM requirements as well as the basis for estimates of potential impact for certain new and expanded requirements. Specifically, the references L&I uses include OSHA's 2013 and 2016 regulatory impact analyses for its potential amendments to PSM standards[45] and the EPA's analyses to its Risk Management Plan (RMP) in 2016,[46] as well as OSHA's rule analyses to its 1992 PSM[47] and the EPA's 1996 RMP economic impact analysis.[48]

Last but not least, L&I heavily relies on the expertise and insight of its internal and external subject matter experts (SMEs) in making major assumptions and estimates. The internal experts are the rule writers and other key L&I employees who provide technical advice and consultations for the rulemaking program. External technical assistances and resources are mainly from the implementation of the first state level PSM regulation by the staff within California Department of Industrial Relations. Detailed discussions about each major requirement and its cost

Act, Wash. Rev. Code § 42.56 et seq., individual information submittals create proprietary risks and potential security concerns." (WSPA Letter, Jan. 28, 2020).

[44] WSPA represented all five refineries in Washington State until February 2020 when BP announced it would withdraw from WSPA and other two trade associations due to materially different policy positions on carbon pricing that cannot be reconciled (https://www.bp.com/en/global/corporate/news-and-insights/press-releases/bp-to-leave-three-trade-associations-after-detailed-review-of-climate-policies.html).

[45] OSHA, 2016. Occupational Safety and Health Administration, Process Safety Management SER Background Document, Available at OSHA docket number OSHA-2013-0020-0107.

[46] EPA, 2016. Environmental Protection Agency, Regulatory Impact Analysis: Accidental Release Prevention Requirements: Risk Management Programs Under the Clean Air Act, Section 112(r)(7), Dec 16, 2016, Available at EPA docket number EPA-HQ-OEM-2015-0725-0734

[47] OSHA, 1992. Occupational Safety and Health Administration, Final Regulatory Impact and Regulatory Flexibility Analysis of the Final Standard for Process Safety Management of Highly Hazardous Chemicals. Available at OSHA docket number OSHA-S026-2006-0659-0743.

[48] EPA, 1996. Environmental Protection Agency, Economic Analysis in Support of Final Rule on Risk Management Program Regulations for Chemical Accident Release Prevention as required by Section 112(3) of the Clean Air Act.

implication have been completed through a series of meetings between the author and these SMEs. Their inputs significantly contribute to the final cost determinations.

3.4 Cost Estimates by Provision

Based on the description of rule amendments in Section 1.3, L&I identified sixteen major requirements in the adopted rule that are associated with significant cost impacts: PSM program, Employee Collaboration, PSI, PHA & SPA, HCA, Operating Procedures, Training, PSSR, MI & RAGAGEP, DMR, MOC, MOOC, RCA, PSCA, Human Factors, and Corrective Action Program. These requirements will be analyzed separately in each subsection below.

It is helpful to first look at some key characteristics of these requirements before analyze their cost impacts. Table 3.6 summarizes the analysis basis and its update & revalidation schedule for each of these elements.

Table 3.6: Scope and Update Schedule for Major Rule Elements

Element	Applicable to	Review / Update / Revalidation Schedule
PSM program	Whole facility	Every 3 years
Employee Collaboration	Whole facility	Ongoing
PSI	Each process	When there is change to the process or process equipment
PHA	Each process	Every 5 years
SPA	For processes associated with each scenario in the PHA that identifies the potential for a process safety incident	If needed, must be completed within 6 months of the completion or revalidation of the PHA
HCA	For all existing processes, as well as recommendations from PHA team, incident investigations, or when a major change is adopted	HCAs for existing processes must be updated and revalidated every 5 years

Operating Procedures	Each process	Operating procedures must be reviewed and updated as often as necessary to ensure that they reflect current, safe operating practices. Annually certified and documented that written operating procedures are current and accurate.
Training	All affected employees	Refresher and supplemental training to each operating employee every three years.
PSSR	For all new processes, certain modified processes, partial or unplanned shutdowns, and all turnaround work	Not specified
MI & RAGAGEP	For process equipment	Must develop, implement, and maintain effective written procedures to ensure the ongoing integrity of process equipment.
DMR	For each existing and new process for which a damage mechanism exists.	Every five years
MOC	For any change in process chemicals, technology, procedures, process equipment and facilities.	Ongoing: whenever there is such change.
MOOC	For any organizational change.	Ongoing: whenever there is such change.
RCA	For any incident that results in, or could reasonably have resulted in, a process safety incident.	Ongoing: whenever there is such incident.
PSCA	For the entire facility	Every five years
Human Factors	For existing operating and maintenance procedures	Must complete 50% of assessments and revisions within three years following the effective date of the rule, and 100% within five years.

3.4.1 PSM Program

This is a new section that requires employers to: 1) designate the refinery manager as the person with authority and responsibility for compliance with the rule; 2) develop, implement, and

maintain an effective written process safety management (PSM) program, and review and update the PSM program at least once every three years; 3) develop, implement, and maintain an organizational chart that identifies management positions responsible for implementing the PSM program elements, and 4) develop, implement and maintain an effective program to track, document, and assess leading and lagging factors and process safety performance indicators.

The first requirement regarding a designated person for the PSM program does not impose new costs as it is similar to what is currently required by EPA's RMP rule.[49] The requirement for an organizational chart is a minor administrative change that will be incorporated into policies and procedures, so it doesn't need to be estimated separately. Current rule already requires documentation of different PSM elements, including the requirement of PSM program development and maintenance, and many pieces of a PSM system.[50] The new rule will only require written documentation for the expanded or new areas adopted, and a coordination of all written documentation into a single system. All refineries are currently required by the EPA's RMP rule to have a similar written risk plan for the process safety management,[51] so much of the written PSM program should already be in place. The requirement of setting up a program to track, document, and assess leading and lagging factors and process safety performance indicators is a key component of a robust PSM program, which will have a significant cost impact on the industry.

- Given the reasons described above, L&I estimates that it will take a PSM team approximately 26-52 weeks to develop the components of the program for the process areas not currently covered by the existing state PSM rule or the risk plan in EPA's RMP standard, and for the processes that are currently covered but need to be modified to

[49] Under 68.15(b) of 40 CFR Chapter I, Subchapter C.
[50] For example, WAC 296-67-013 states that employers are required to complete a compilation of written process safety information before conducting any process hazard analysis and WAC 296-67-045 states that employers must establish and implement written procedures to manage changes to process chemicals, technology, equipment, procedures, and changes to facilities that affect a covered process.
[51] See Section 68.15 of EPA RMP Rule under 40 CFR Chapter I, Subchapter C.

incorporate adopted new components for a typical Washington refinery.[52] Therefore, the total labor time required for the whole industry are approximately 14,446 - 28,891 hours.

- Given that API has already identified and published the leading and lagging process safety indicators used for driving performance improvement for the refining industry,[53] the initial labor burden for setting up this tracking system is estimated to be roughly a half of the time needed for the PSM program development. This translates into 1,560 - 3,120 hours for a typical refinery, and 7,223 - 14,446 hours for the entire industry.
- The ongoing labor burden of reevaluating, modifying and maintaining the PSM program and the performance tracking system decreases every three year as described in Section 3.2.4. For all other years, the ongoing labor burden is 33% of the hours needed for setting up the initial PSM program and performance tracking system.
- All-together, the total labor time invested in the 10-year period for the PSM program is 98,860 - 197,720 hours for the entire industry.

Table 3.7: Labor Burden for PSM Program –Industry Estimates

Cost Components	Low	High
Initial labor burden		
for developing the PSM program	14,446	28,891
for setting up the PI tracking system	7,223	14,446
Ongoing labor burden for reevaluating, modifying and maintaining the PSM program and PI system		
Year 2	7,151	14,301
Year 3	7,151	14,301
Year 4	17,335	34,669
Year 5	5,720	11,441
Year 6	5,720	11,441

[52] Unless otherwise stated, a typical refinery in Washington throughout the entire report is the one represented by the third largest refinery in the state. This refinery also has the capacity closest to the average among all five plants.
[53] API, 2016. American Petroleum Institute. "Recommended Practice 754: Process Safety Performance Indicators for the Refining and Petrochemical Industries," 2nd ed. April 2016, available at https://www.api.org/oil-and-natural-gas/health-and-safety/refinery-and-plant-safety/process-safety/process-safety-standards/rp-754 (accessed February 13, 2020).

Year 7	13,868	27,736
Year 8	4,576	9,153
Year 9	4,576	9,153
Year 10	11,094	22,188
Total hours over 10-year period	**98,860**	**197,720**

3.4.2 Employee Collaboration

Refineries are currently required under WAC 296-67-009 to have a written plan for employee participation and to consult with employees and their representatives in the process of performing PHA and other elements of process safety management. Refineries are already required under chapter 296-800 WAC to develop a formal accident prevention program, establish and conduct safety committees, provide employees with appropriate PPEs and training, and provide their employees a workplace free from recognized hazards that are causing, or are likely to cause, serious injury or death. The current EPA's RMP rule also has similar requirements for employee participation.

The amendment to this section will require that employers revise the written plan to provide for employee collaboration in PSM program development and implementation planning, as well as to provide effective collaboration by affected operating and maintenance employees, throughout all phases, in performing various tasks. Additionally, the employer will need to develop procedures for a Stop Work Authority (SWA), and implement a corresponding training program.

Initial labor hours for developing the new written plan for employee collaboration beyond what is currently in place for employee participation, developing SWA procedures, and conducting training combined is estimated to be about 30% of the labor burden of developing the PSM program.[54] Therefore, it requires approximately 936 - 1,872 hours for a typical refinery and 4,334 - 8,667 hours for the entire industry to perform these tasks.

[54] Based on the survey response from WSPA.

Ongoing labor burden of employee collaboration activities on major elements of the PSM rule such as PHA, SPA, DMR, HCA, MOC, MOOC, PSCA, Incident investigation, PSI, and PSSR is assumed to be 10% of annual labor burden estimated for each specific requirement. Adding the initial labor burden, the total labor time required for the Employee Collaboration is 101,236 - 170,583 hours for the entire industry over the 10 year period.

Table 3.8: Labor Burden for Employee Collaboration –Industry Estimates

Cost Components	Low	High
Initial labor burden of developing the new written plan for employee collaboration, developing SWA procedures, and conducting training	4,334	8,667
Ongoing labor burden of collaboration on all major elements		
Year 2	10,079	17,030
Year 3	10,079	17,030
Year 4	10,079	17,030
Year 5	10,079	17,030
Year 6	17,910	28,840
Year 7	9,669	16,239
Year 8	9,669	16,239
Year 9	9,669	16,239
Year 10	9,669	16,239
Total hours over 10-year period	101,236	170,583

3.4.3 Process Safety Information

Refineries are currently required under WAC 296-67-013 to complete a compilation of written process safety information (PSI) before conducting any process hazard analysis. This section also specifies various types of required information regarding the hazards of the highly hazardous chemicals used or produced by the process, information regarding the technology of the process, and information regarding the equipment in the process. The current EPA's RMP rule also has similar requirements for PSI.

The major amendments to this section includes:

- First, the PSI must include results of previous DMRs, and the information pertaining to the hazardous chemicals or materials used in, present in, or produced by the process, must include damage mechanism data. This will impose a small additional labor burden as the specific information can be retrieved from the DMR requirement under the adopted WAC 296-67-347.
- Second, employers are required to include information on the design conditions and operating limits, electrical supply and distribution systems, of equipment in the process. L&I estimates that preparing and adding the additional information for each process will take the three-employee team anywhere from two to six weeks for a typical refinery.[55] Therefore, the total initial labor burden for the whole industry is 13,985 - 41,954 hours for this element.
- Third, if the employer installs new process equipment for which no RAGAGEP exists, employer must determine and document that the equipment is designed, constructed, installed, maintained, inspected, tested and operated in a safe manner. L&I does not think this happens often and if it happens, the statement that the equipment is designed, constructed, installed, maintained, inspected, tested and operated in a safe manner is an implicit requirement from the existing mechanical integrity and maintenance standards for the equipment. So there is no additional cost from this amendment.
- Lastly, employers must provide for employee collaboration and make PSI available to all employees. Information pertaining to the hazards of the process must be effectively communicated to all affected employees, including contractor employees. The emphasis on making PSI available and well communicated to all employees is a relatively easy task and will only require a small amount of administrative time when the PSI is in place. Taking this into consideration, L&I estimates it will take 16 - 24 hours each year for a typical refinery to fulfill this task and 74 - 111 hours for the entire industry.

[55] The lower bound estimate is based on the average of 208 hours per process for PSI requirement from OSHA (2016), and the upper bound estimate is based on the 700 hours per process estimated by WSPA.

The ongoing cost of maintaining the information required in this section and making it available to all employees are estimated to be 33% of the initial labor time, which translates into 4,639 - 13,880 hours industrywide each year.

All-together, the total labor time invested in the 10-year period for the PSI related tasks is 55,810 – 166,986 hours for the entire industry.

Table 3.9: Labor Burden for PSI –Industry Estimates

Cost Components	Low	High
Initial labor hours for		
preparing and adding additional information of equipment in the process	13,985	41,954
making PSI available to all employees	74	111
Ongoing labor burden for maintaining the PSI requirement		
Year 2	4,639	13,880
Year 3	4,639	13,880
Year 4	4,639	13,880
Year 5	4,639	13,880
Year 6	4,639	13,880
Year 7	4,639	13,880
Year 8	4,639	13,880
Year 9	4,639	13,880
Year 10	4,639	13,880
Total hours over 10-year period	55,810	166,986

3.4.4 Process Hazard Analysis and Safeguard Protection Analysis

The PHA element is the heart of the PSM program and also one of the most costly requirements due to its scope and relationship with other major rule elements. PHAs are required for all covered processes under the current rule. Under the adopted rule, costs associated with conducting PHAs will increase from two major sources: processes not previously covered will require PHAs, and additional information, such as DMR and HCA reports that are applicable to

the specific process, must be addressed and incorporated into the analysis for each process including the processes covered by the current rule.[56]

WAC 296-67-323 also requires that employers perform an effective written SPA for each scenario in the PHA that identifies the potential for a process safety incident,[57] using quantitative or semi-quantitative method such as Layer of Protection Analysis (LOPA). The SPA can be performed as part of the PHA or as a stand-alone analysis. Given that SPAs are triggered by and closely related to the results of PHAs, L&I assumes the refineries will incorporate SPAs into the PHAs required for each process.

L&I assumes it would require a team of seven members mixed of PSM managers, engineers with expertise in specific PHA and SPA methodologies, specialists, and the affected operating employees, to work three to four full weeks to develop a new PHA for each currently uncovered process.[58] The labor burden for addressing and incorporating the additional required information to the PHAs for each currently covered process is estimated to be 50% by the same team. Given the number of currently covered and the newly covered processes estimated in Section 3.2.2, the initial labor burden of bringing all PHAs to the compliance with the adopted rule amounts to 7,560 - 10,080 hours for a typical refinery, or 33,793 - 45,058 hours for the whole industry.

With regard to SPAs, the industry has indicated some refineries may have already conducted SPAs for high risk process units and for high risk & high consequence scenarios, and existing safeguards are likely adequate although not most protective. Based on the estimate of one to two weeks of labor time for the same seven-employee team to conduct the identified SPA

[56] In practice, the scope and contents of PHAs vary significantly between companies. Some companies will conduct a comprehensive PHA for each process, while others might conduct multiple smaller PHAs on the same process unit (Bridges, 1994). For simplicity, we assume that there is one comprehensive PHA covering each process and estimate costs accordingly, similar to what OSHA (1992, 2016) and EPA (1996) did.
[57] An event within or affecting a process that causes a fire, explosion or release of a hazardous chemical or material and has the potential to result in death or serious physical harm.
[58] The lower bound is estimated based on a suggested PHA team composition and time estimates for conducting HAZOP analysis given by "Guidelines for Hazard Evaluation Procedures," The 3rd Edition (AIChE/CCPS, 2008). This estimate (840 hours) is also within the range of 755-1,135 hours that WSPA estimated for each PHA. The upper bound is estimated based on the suggestions from Cal/OSHA.

components for each process,[59] the total initial labor hours for SPAs would be 3,640 - 7,280 per refinery and 16,316-32,631 for the whole industry.

The rule also requires that all PHAs, including the SPA component if any, must be revalidated every five years. Given the cost reduction rates for each revalidation year and all other years explained in Section 3.2.4, the total labor time required in the 10-year period for PHA and SPA related tasks is 209,550 - 324,822 hours for the entire industry.

Table 3.10: Labor Burden for PHA and SPA –Industry Estimates

Cost Components	Low	High
Initial labor hours for		
developing new PHAs	18,640	24,853
incorporating additional info to current PHAs	15,154	20,205
adding SPAs to the PHAs	16,316	32,631
Ongoing labor burden for maintaining and updating all PHAs &SPAs		
Year 2	16,567	25,678
Year 3	16,567	25,678
Year 4	16,567	25,678
Year 5	16,567	25,678
Year 6	40,161	62,250
Year 7	13,253	20,543
Year 8	13,253	20,543
Year 9	13,253	20,543
Year 10	13,253	20,543
Total hours over 10-year period	209,550	324,822

[59] This is based on the average of labor hour estimates (405 hours) provided by WSPA for conducting SPAs.

3.4.5 Hierarchy of Hazard Controls Analysis

The hierarchy of hazard controls analysis (HCA) requirement is a foundation of the PSM rule, alongside the process hazard assessment (PHA), and is one of the most important new requirements in this adopted rule. Under this section, refineries are required to perform HCAs as stand-alone analyses for all existing processes. HCAs are also required under the following circumstances: 1) applicable recommendations from a PHA; 2) applicable recommendations from an incident investigation; 3) as part of a Management of Change (MOC) analysis for major changes; and 4) as part of the design and review of new processes, process units, facilities, and equipment. All initial HCAs for existing processes must be completed within five years of the effective date of the rule, and other HCAs must be performed in a timely manner. Each analysis must also be revalidated at least every five years.

L&I assumes it will take a 6-employee team as described in Table 3.4 an average of four to six weeks to conduct the initial analyses for each process based HCA, including those recommended by a PHA team and those triggered by major changes on certain processes.[60] Therefore, the initial labor burden of conducting required HCAs for all processes amounts to 12,480 - 18,720 hours for a typical refinery, or 55,939 - 83,909 hours for the whole industry. As to the labor burden of performing a stand-alone HCA as a result of incident investigation,[61] L&I adopted EPA's (2016) labor model for conducting a safer technology alternatives analysis (STAA), similar to the HCAs required here. More specifically, it would take the team approximately two to three weeks to conduct a STAA for a large refinery, [62] which is used as the labor burden per HCA from the recommendation of incident investigations.[63] L&I also estimates that an average

[60] Based on discussions with internal technical staff as well as external experts from Cal/OSHA.
[61] The labor burden to conduct the HCA for design and review of new processes, new process units, and new facilities is not analyzed here as these are rare occurrences.
[62] The STAA provision would require the owners or operators to conduct analyses of potential safer technologies and alternatives and a determination of feasibility of implementation of any inherently safer technologies (IST). It would require them to consider process hazard controls in the following order of preference: inherently safer technology or design, passive measures, active measures, and procedural measures (OSHA and EPA, 2016). The estimated average time for conducting a STAA was 608 hours in EPA's analysis.
[63] The labor burden per HCA will remain the same each year (i.e., it is not subject to the assumption for the ongoing costs)

of five HCAs from the incident investigations would be recommended each year in a refinery.[64] Hence, the annual labor burden of conducting these HCAs will be 2,400 - 3,600 hours for a typical refinery, or 11,112 - 16,668 hours for the whole industry.

Based on these cost factors, the total labor time required for all HCAs in the 10-year period is in the range of 355,732 - 533,598 hours for the entire industry. This makes the HCA requirement the most burdensome element in this adopted PSM rule (see Table 3.20), consistent with the results of Rand's study on the California PSM rule.[65]

Table 3.11: Labor Burden for HCAs–Industry Estimates

Cost Components	Low	High
Initial labor burden for performing all process related HCAs	55,939	83,909
Annual labor burden for performing incident investigation related HCAs	11,112	16,668
Ongoing labor burden for maintaining and updating all HCAs		
Year 2	29,217	43,826
Year 3	29,217	43,826
Year 4	29,217	43,826
Year 5	29,217	43,826
Year 6	55,509	83,263
Year 7	29,075	43,616
Year 8	29,075	43,616
Year 9	29,075	43,616
Year 10	29,075	43,616
Total hours over 10-year period	355,732	533,598

[64] Multiple sources contributed to these estimates including OSHA (2016), WSPA, and the PSM unit of Cal/OSHA.
[65] Gonzales et al. 2016, p. 32.

3.4.6 Operating Procedures

Under the current rule, employers are required to have operating procedures that cover steps for each operating phase, operating limits, safety and health considerations, and safety systems and their functions. Operating procedures must also develop and implement safe work practices. Additionally, the operating procedures must be kept current, and certified annually to be accurate and made available to employees who work in or maintain a process.

The adopted amendments would expand this section by adding procedures for start-up after planned or unplanned shutdowns and non-routine work, incorporating stating the minimum number of employees required to safely execute the procedure and humans factors considerations for safety and health considerations, including emergency procedures in the operating procedures for each process, and developing safe work practices for dealing with releases of hazardous chemicals and materials. Other changes are primarily formal stipulations of requirements in other sections of PSM or other applicable rules.

According to OSHA, the labor burden for a large refinery to develop written procedures for each process was estimated to be 117 hours.[66] Given the added contents required by the adopted rule, L&I estimates the labor time needed to complete all required components for a new process would be two to three times that labor burden. Combined with the currently covered and newly covered process estimates for a typical refinery, the initial labor burden of bringing all operating procedures up to compliance with the adopted rule amounts to 2,106 - 2,691 hours per refinery, or 9,414 - 12,010 hours for the whole industry.

Given the assumption on the recurring maintenance costs, the ongoing labor burden is estimated at a range of 3,115 - 3,980 hour for the industry each year. Adding the initial time estimate, the total labor burden of all operating procedure related tasks amounts to 37,450 - 47,834 hours over the 10-year period.

[66] Table IV-2a, OSHA (2016).

Table 3.12: Labor Burden for Operating Procedures–Industry Estimates

Cost Components	Low	High
Initial labor burden for		
developing OPs for new processes	5,192	7,789
updating the existing OPs for current processes	4,221	4,221
Ongoing labor burden for maintaining and updating all OPs		
Year 2	3,115	3,980
Year 3	3,115	3,980
Year 4	3,115	3,980
Year 5	3,115	3,980
Year 6	3,115	3,980
Year 7	3,115	3,980
Year 8	3,115	3,980
Year 9	3,115	3,980
Year 10	3,115	3,980
Total hours over 10-year period	37,450	47,834

3.4.7 Training

Under the current rule, employees involved in operating a process must be trained in an overview of the process and in the operating procedures, and on safety considerations applicable to the employees' tasks. These employees are also required to receive refresher training at least every three years. Significant new training costs result from the following amendments to the current rule: 1) the provision that requires each affected employee involved in the maintenance of a process and each affected employee prior to performing work within a newly assigned process be trained in an overview of the process and in the hazards and safe work practices related to the process, 2) the provision that requires maintenance employees receive refresher training every three years, and 3) the employers must develop, implement, and maintain an effective written program to include the requirements for qualified employees, the testing procedures to verify

understanding and competency of employees in job skill levels and work practices, and to ensure that all affected employees are aware of and understand all PSM elements described in this rule.

Lacking the data on the actual number and share of maintenance workers at each refinery facility, L&I assumes all refinery employees will need to receive an average of 18-32 hours of initial training and 1 hour of refresher training every three years as a result of the adopted rule amendments.[67] Given the actual number of employees in each Washington refinery, the labor burden of initial training is estimated to be 40,590 - 72,160 hours, and the refresher training is expected to take 752 labor hours annually for the industry. Additionally, the initial burden of developing a written training program that includes all the required components is estimated to be five to six weeks by two engineers for a typical refinery, so the labor burden for the whole industry amounts to 1,754 - 2,104 hours.[68]

Given all these cost factors and the average of 18.8% annual turnover rate,[69] the total labor burden of the adopted training requirement is estimated to be in the range of 117,787 - 203,124 hours for the whole industry over the 10-year period.

Table 3.13: Labor Burden for Training Requirement–Industry Estimates

Cost Components	Low	High
Initial labor burden		
for initial training for all employees	40,590	72,160
for developing training program	1,754	2,104
Ongoing labor burden of all required training		
Year 2	8,383	14,318
Year 3	8,383	14,318

[67] These training hour estimates were from WSPA's survey responses (2020). The training requirement for contractors and subcontractors of refineries is specified under chapter 49.80 RCW (i.e., it is dictated by the statute, not this adopted rule). Therefore, the training cost for contractors and subcontractors is not considered in this section.
[68] Estimates from L&I internal technical experts. Verification of employee training is already required by the current rule, so the employee testing requirement is not expected to add significant ongoing cost. The cost of training employees for collaboration in the various PSM elements is attributed to those elements.
[69] Data from Financeonline.com (https://financesonline.com/employee-turnover-statistics/).

Year 4	8,383	14,318
Year 5	8,383	14,318
Year 6	8,383	14,318
Year 7	8,383	14,318
Year 8	8,383	14,318
Year 9	8,383	14,318
Year 10	8,383	14,318
Total hours over 10-year period	117,787	203,124

3.4.8 Pre-Startup Safety Reviews

Pre-Startup safety review (PSSR) is a current requirement for new facilities and for modified facilities when the modification is significant enough to require a change in the process safety information. The adopted rule expands this section to require a PSSR for partial or unplanned shutdowns.

- The employer must also perform a PSSR for all turnaround work performed on a process. Other adopted changes include that
- The PSSR must confirm that:
    - Process equipment has been maintained, prepared for start-up, and is operable in accordance with design specifications;
    - A PHA, HCA, DMR, and SPA have each been performed, as applicable, and
    - Recommendations have been implemented or resolved before start up for new processes; and affected employees must be involved in the process.

For the expansion of PSSRs to partial or unplanned shutdowns and turnaround work performed on a process, L&I estimates each year, there will be 21 PSSRs that need to be conducted.[70] L&I also assumes the team performing the PSSRs consists of a process engineer, an operator, and a

[70] WSPA's survey responses (2020).

maintenance worker. Depending on the complexity of issues involved in the reviews, it will take 8-16 hours for the team to complete each PSSR in the first year.[71] So the total initial labor burden to conduct all required PSSRs is 2,520 - 5,040 hours for a typical refinery and 11,668 - 23,335 for the whole industry.

Given all these estimates and the assumption on the recurring costs, the total labor burden of the adopted PSSR requirement is estimated to be in the range of 46,320 - 92,641 hours for the whole industry over the 10-year period.

Table 3.14: Labor Burden for PSSR Requirement–Industry Estimates

Cost Components	Low	High
Initial labor burden for performing PSSRs	11,668	23,335
Ongoing labor burden of PSSR requirement		
Year 2	3,850	7,701
Year 3	3,850	7,701
Year 4	3,850	7,701
Year 5	3,850	7,701
Year 6	3,850	7,701
Year 7	3,850	7,701
Year 8	3,850	7,701
Year 9	3,850	7,701
Year 10	3,850	7,701
Total hours over 10-year period	46,320	92,641

3.4.9 Mechanical Integrity

The major changes to the existing MI section include the requirement that 1) employers must document and ensure that this equipment is designed, constructed, installed, maintained, inspected,

[71] From L&I internal technical experts. This unit labor hour estimate is significantly higher than the estimates in OSHA PSM RIA and EPA RMP rule analyses for performing a PSSR.

tested and operated in a safe manner if they install new process equipment or has existing process equipment for which no recognized and generally accepted good engineering practices (RAGAGEP) exists; 2) employers must establish a process for evaluating new or updated codes and standards and implementing changes as appropriate to ensure safe operation, and 3) once an equipment deficiency or failure mechanism is identified, substantially similar equipment in similar service must be evaluated for the same deficiency or failure mechanism.

The provision specified in 1) above is already the responsibility of employers and the language here only serves as a formal manner of documenting this requirement, so there is no new cost associated with it. For the requirement specified in 2), refineries are already required to follow RAGAGEP, so the primary cost is for personnel to develop a formal procedure for the whole facility. L&I estimates that a team consisting of an inspections manager, a staff engineer, an operations supervisor as well as a maintenance supervisor will spend 24-40 hours in developing written procedures. For the requirement regarding equipment deficiency or failure, L&I estimates that such an event would occur four times per year on average at a typical facility, and each occurrence will require two operations workers and two maintenance workers to spend 7-10 work days to inspect and evaluate all other pieces of equipment similar to the one at fault. [72]

Given all these estimates, the total labor burden of the adopted Mechanical Integrity requirement is estimated to be in the range of 41,929 - 60,005 hours for the whole industry over the 10-year period.

Table 3.15: Labor Burden for MI Requirement–Industry Estimates

Cost Components	Low	High
Initial labor burden for developing formal procedures for MI	444	741
Initial labor burden for addressing equipment deficiency or failure issues	4,148	5,926
Ongoing labor burden	4,148	5,926
Year 2	4,148	5,926
Year 3	4,148	5,926

[72] All the labor hour estimates are from L&I internal technical experts.

Year 4	4,148	5,926
Year 5	4,148	5,926
Year 6	4,148	5,926
Year 7	4,148	5,926
Year 8	4,148	5,926
Year 9	4,148	5,926
Year 10		
Total hours over 10-year period	41,929	60,005

3.4.10 Damage Mechanism Review

DMR is a key addition to the PSM standards. Under the adopted rule, DMRs are required for all existing and new processes for which a damage mechanism exists and must be revalidated at least once every five years. Additional DMRs may be required when major process changes introduce a damage mechanism and where a damage mechanism identified as contributing factor in an incident investigation.

L&I assumes a team of three employees consisting of a senior-level engineer, an operations worker, and a worker knowledgeable in the specific DMR methodology will conduct DMRs, and it will take an average of 8-12 weeks for the team to complete an initial review for each process for all process related DMRs, including those triggered by major change on a certain process.[73] Assuming a damage mechanism exists for each current and new process, the initial labor burden of completing all process related DMRs amounts to 12,480 - 18,720 hours per refinery and 55,939 - 83,909 hours for the whole industry.

L&I also estimates that each year, an average of nine DMRs will be recommended from incident investigations by each refiner.[74] Based on the estimated average of two weeks for the team to

[73] From L&I and Cal/OSHA (2022).
[74] WSPA's survey responses (2020).

perform each review, the total annual labor burden for these DMRs is 2,160 hours per refinery and 10,001 hours for the whole industry.

Altogether, the total labor burden of all DMR related tasks amounts to 343,519 -460,320 hours over the 10-year period.

Table 3.16: Labor Burden for DMR Requirement–Industry Estimates

Cost Components	Low	High
Initial labor burden for conducting all processes related DMRs	55,939	83,909
Initial labor burden for incident investigation related DMRs	10,001	10,001
Ongoing labor burden for updating and revalidating all DMRs		
Year 2	28,142	37,372
Year 3	28,142	37,372
Year 4	28,142	37,372
Year 5	28,142	37,372
Year 6	54,433	76,809
Year 7	27,645	35,029
Year 8	27,645	35,029
Year 9	27,645	35,029
Year 10	27,645	35,029
Total hours over 10-year period	343,519	460,320

3.4.11 Management of Change

While Management of Change (MOC) reviews are required under the current rule, the adopted rule contains new requirements including that potential safety impacts of the change be addressed and documented; modifications of maintenance procedures or development of new operating or maintenance procedures be addressed and documented; and a DMR and HCA be conducted and reviewed prior to implementing a major change and the findings from these reports be included in the MOC documentation. The affected businesses will incur new

compliance costs for integrating these added elements and requirements into the MOC procedures for future changes and major changes that may occur.

L&I estimates that conducting a typical MOC will require 20 hours from a senior engineer.[75] L&I also estimates that each process will be subject to 3-11 changes per year in a refinery.[76] Based on these two estimates, L&I anticipates that the total labor burden from the revised MOC provision is in a range of 34,962 - 128,194 hours for the industry over a 10-year period.

Table 3.17: Labor Burden for MOC Requirement–Industry Estimates

Ongoing labor burden for conducting required MOCs	Low	High
Year 1	3,496	12,819
Year 2	3,496	12,819
Year 3	3,496	12,819
Year 4	3,496	12,819
Year 5	3,496	12,819
Year 6	3,496	12,819
Year 7	3,496	12,819
Year 8	3,496	12,819
Year 9	3,496	12,819
Year 10	3,496	12,819
Total hours over 10-year period	34,962	128,194

3.4.12 Management of Organizational Change

Management of Organizational Changes (MOOCs) is a new requirement in the adopted rule. Under this section, employers are required to develop, implement and maintain effective written procedures to manage organizational changes. Employer must also designate a team to perform an

[75] Based on the average labor hour estimated by WSPA.
[76] The lower bound was from OSHA's estimates for a large refinery (1992, 2016), and the upper bound was based on WSPA's estimated MOCs per process.

assessment prior to making certain organizational changes such as reducing staffing levels and changing shift duration, and to certify the MOOC is accurate and the adopted organizational change meets the requirements of WAC 296-67-359.

L&I estimates that conducting and certifying a MOOC will require 22-34 hours from a refinery manager, and there is an average of eight assessments per refinery each year.[77] So the total labor burden from the MOOC provision is in a range of 8,149 - 12,594 hours for the industry over a 10-year period.

Table 3.18: Labor Burden for MOOC Requirement–Industry Estimates

Ongoing labor burden for conducting required MOOCs	Low	High
Year 1	815	1,259
Year 2	815	1,259
Year 3	815	1,259
Year 4	815	1,259
Year 5	815	1,259
Year 6	815	1,259
Year 7	815	1,259
Year 8	815	1,259
Year 9	815	1,259
Year 10	815	1,259
Total hours over 10-year period	8,149	12,594

3.4.13 Incident Investigations and Root Cause Analysis

Incident investigation is an existing provision under which investigations must be conducted for each incident which resulted in, or could reasonably have resulted in a catastrophic release of highly hazardous chemical in the workplace. The adopted rule now requires investigations be

[77] Based on the estimates from WSPA's survey responses.

conducted for "process safety incidents".[78] Refineries will need to develop and write procedures and investigation reports based on a more thorough root cause analysis, including identifying management system failures, identifying the initiating and underlying causes of an incident, as well as having the reports available to affected employees and be retained for the life of the processes.

The most recent BLS data (2020) shows the recordable incident rate for the petroleum refining industries was 0.5 injury incident per 100 employees.[79] Assuming non-injury incidents are five times that rate, a Washington refinery with 400 employees will have 12 incidents in a typical year. L&I also assumes an investigation team comprised of an employee qualified in the process involved in the investigation, an employee qualified to perform the root cause analysis method and a manager or supervisor qualified to oversee the investigation and analysis will need additional two to four weeks to conduct the RCAs for each incident investigation.[80]

Based on these factors, L&I anticipates that the total labor burden from the revised Incident Investigation & RCA provision is 133,344 - 266,688 hours over a 10-year period for the industry.

Table 3.19: Labor Burden for Incident Investigations / RCAs - Industry Estimates

Ongoing labor burden for conducting required RCAs	Low	High
Year 1	13,334	26,669
Year 2	13,334	26,669
Year 3	13,334	26,669
Year 4	13,334	26,669
Year 5	13,334	26,669
Year 6	13,334	26,669

[78] Process safety incident is defined in the adopted rule as "an event within or affecting a process that causes a fire, explosion or release of a hazardous chemical or material and has the potential to result in death or serious physical harm."
[79] Table 1: Incidence rates of nonfatal occupational injuries and illnesses by industry and case types, Survey of Occupational Injuries and Illnesses Data, BLS, 2020.
[80] Derived from multiple sources including the estimates from EPA RMP rule analysis (1996) and Cal/OSHA (2022).

Year 7	13,334	26,669
Year 8	13,334	26,669
Year 9	13,334	26,669
Year 10	13,334	26,669
Total hours over 10-year period	133,344	266,688

3.4.14 Process Safety Culture Assessment

PSCA is a new requirement in the adopted rule with the purpose of gauging the degree to which a refinery prioritizes safety alongside other production pressures, such as cost, efficiency, and competitiveness. Process safety culture is a combination of group values and behaviors that indicate whether there is a collective commitment by leaders and individuals to emphasize safety over competing goals, in order to ensure protection of people and the environment.
The rule requires that employers develop, implement, and maintain an effective process safety culture program, and produce a written report that includes methods, findings, and recommendations for corrective actions. The rule also directs employers to perform a PSCA at least once every five years.

L&I assumes the initial development of the PSCA will be led by an outside consultant specializing in cultural assessments, and the average cost of developing a PSCA for a typical refinery is $150,000.[81] As required, refineries will bear this cost every five years. Additional initial costs stem from the labor burden of refineries' internal employees collaborating and working with the consultant throughout the assessment process for the development and implementation of PSCA**.** L&I estimates this will require an average of four to six weeks for a team made up of an internal PSCA specialist, a PSM manager, and an operations employee to conduct an initial employee survey and assist the consultant with other administrative tasks for the culture assessment, as well as 45 minutes per employee for all the employees to complete the initial survey or interview.[82] Therefore**,** the total initial labor burden for PSCA requirement is 773 - 1,013 hours per refinery and 3,914 - 5,025 hours for the whole industry.

[81] From WSPA (2020).
[82] From L&I internal technical experts.

Given the assumption on the recurring maintenance costs and the five-year cycle for the PSCA revalidation, the total labor burden of all PSCA related tasks is 12,055 - 16,696 hours and the cost of hiring outside consultant amounts to $1.39 million for the industry over the 10-year period.

Table 3.20: Summary of Cost of Compliance with PSCA Requirement–Industry Estimates

Cost Components	Low	High
Initial cost of hiring outside consultant in developing the PSCA	$694,500	$694,500
Initial labor burden of developing and implementing PSCA	2,222	3,334
Initial labor burden of all employees completing the survey for PSCA	1,691	1,691
Ongoing labor burden for implementing and maintaining PSCA		
Year 2	733	1,100
Year 3	733	1,100
Year 4	733	1,100
Year 5	733	1,100
Year 6	2,861	3,750
Year 7	587	880
Year 8	587	880
Year 9	587	880
Year 10	587	880
Total cost of hiring outside consultant in 10 years	$1,389,000	$1,389,000
Total labor burden (hours) in 10 years	12,055	16,696

3.4.15 Human Factors

Human factors (HFs) are assessed as part of the current PHA process. Under the adopted rule, employers will be required to: 1) develop, implement, and maintain a stand-alone human factors program, 2) assess human factors for all existing, revised, and new operating and maintenance procedures, 3) train affected employees in the written human factors program, and 4) make the program available to affected employees.

Initial labor burden of this requirement include assessing and modifying existing procedures for impacts associated with human factors for all process units. Given the fact that many human factors, such as the complexity of tasks, the length of time needed to complete the tasks, the level of training, experience, and expertise of employees performing the tasks, the human-machine and human-system interface, and the physical challenges of the work environment in which the task is performed, have already been considered and analyzed as integral part of the current procedure development process, L&I estimates that on average, it would take 176 - 648 hours for conducting required analysis for other factors involved in each process unit.[83] Combined with the number of process estimated for a typical refinery, the initial labor burden of bringing all HF analyses to the compliance with the adopted rule amounts to 2,288 - 8,424 hours per refinery, or 10,256 - 37,759 hours for the whole industry.

Given the assumption on the recurring maintenance costs, the ongoing labor burden is estimated at a range of 3,384 - 12,460 hours for the industry each year. Adding the time required for the initial year, the total labor burden for all operating procedure related tasks amounts to 40,714 - 149,903 hours over the 10-year period.

Table 3.21: Labor Burden for HF Requirement - Industry Estimates

Cost Components	Low	High
Initial labor burden of conducting HF analyses for all processes	10,256	37,759
Ongoing labor burden of implementing and maintaining HF program	3,384	12,460
Year 2	3,384	12,460
Year 3	3,384	12,460
Year 4	3,384	12,460
Year 5	3,384	12,460
Year 6	3,384	12,460
Year 7	3,384	12,460

[83] Data source: "Guidelines for Hazard Evaluation Procedures" Chapter 9, (AIChE / CCPS, 2008). The analyses is expected to involve a HF specialist and both a maintenance worker and operator from the process unit. For more complex units, a process and/or maintenance engineer might also participate in the review.

Year 8 Year 9 Year 10	3,384 3,384	12,460 12,460
Total hours over 10-year period	40,714	149,903

3.4.16 Corrective Action Program

This adopted rule creates a new section that requires employers to develop, implement and maintain an effective written Corrective Action Program (CAP) to prioritize and implement recommendations from PHAs, SPAs, DMRs, HCAs, Incident Investigations, and Compliance Audits. For each changed or rejected recommendation, employers must document all instances where any one of the criteria is used, all written comments received from team members, and a final decision for each recommendation. Employers are required to communicate or make the information available to team members involved. Employers must also develop and document corrective actions to implement each accepted recommendation.

Initial costs of having this program in place include administrative burden of developing the written corrective action program. In addition, refiners may need to acquire or develop software for tracking recommendations and corrective actions. Ongoing labor burden results from reviewing recommendations from various analyses and addressing the appropriate corrective actions.

L&I assumes that a five-employee team consisting of a plant manager, an engineer, a maintenance manager, an operations supervisor, and an employee representative will need to spend an average of four to six weeks to set up the initial program, and the ongoing labor burden of reviewing and analyzing the specific recommendations from PHAs, SPAs, DMRs, and HCAs and Incident Investigations is estimated to be 10% of time required for each element in each specific year. In addition, the cost of software for tracking recommendations and corrective actions is estimated at $30,000 - $60,000 per facility and the annual maintenance cost is about 10% of the initial purchase cost, or $3,000 - $6,000 a year.[84]

[84] Data source: PHMSA, 2009.

Given all these factors and the assumption on the recurring maintenance costs, the initial labor burden is estimated at 3,704 - 5,556 hours for the whole industry and the total labor time required is 107,918 - 164,099 hours over the 10-year period. The total cost of purchasing and maintaining software amounts to $285,000 - $570,000 over the same time period.

Table 3.22: Summary of Cost of Corrective Action Program – Industry Estimates

Cost Components	Low	High
Initial cost of purchasing software	$150,000	$300,000
Initial labor burden of setting up the program	3,704	5,556
Ongoing labor burden for implementing and maintaining CAP		
Year 1	19,643	29,884
Year 2	8,726	13,354
Year 3	8,726	13,354
Year 4	8,726	13,354
Year 5	8,726	13,354
Year 6	16,344	24,899
Year 7	8,331	12,585
Year 8	8,331	12,585
Year 9	8,331	12,585
Year 10	8,331	12,585
Total cost in software over 10-year period	$285,000	$570,000
Total labor burden (hours) over 10-year period	107,918	164,099

3.4.17 Other Components of Adopted Rule

There are other elements that are also adopted in this rule. But the compliance costs associated with these elements are relatively small and will not be analyzed separately. Instead, L&I

assumes the aggregated cost of complying with these requirements to be 10% of the total costs from the major elements analyzed in each section above.[85]

3.5 Summary of Compliance Cost of Adopted Rule

Based on the estimates of each major rule element from Section 3.4 and the hourly rate described in Section 3.2.5, the adopted rule is expected to impose a total compliance cost of $189.55 million - $324.40 million on all five refineries in Washington over the next 10 years. Converting this to the net present value and using the real discount rate of 7%,[86] the annual cost of the rule ranges from $23.57 million to $40.34 million.

Table 3.23: Summary of Compliance Cost of the Rule

Rule element	Total cost -Low	Share of total - Low	Total cost -High	Share of total - High
PSM Program	$9,926,350	5.2%	$19,852,700	6.1%
Employee collaboration	$10,164,897	5.4%	$17,127,976	5.3%
PSI	$5,603,772	3.0%	$16,766,723	5.2%
PHA & SPA	$21,040,534	11.1%	$32,614,853	10.0%
HCA	$35,718,416	18.8%	$53,577,624	16.5%
OP	$3,760,274	2.0%	$4,802,914	1.5%
Training	$7,334,985	3.9%	$12,649,218	3.9%
PSSR	$4,650,947	2.5%	$9,301,895	2.9%
MI & RAGAGEP	$4,210,045	2.2%	$6,024,977	1.9%
DMR	$34,492,132	18.2%	$46,219,921	14.2%
MOC	$3,510,473	1.8%	$12,871,735	4.0%
MOOC	$818,207	0.4%	$1,264,501	0.4%
RCA	$13,388,837	7.1%	$26,777,675	8.2%

[85] Similar to the estimated cost share for other components in California PSM rule analysis (Gonzales et al, 2016).
[86] This was the discount rate U.S. Department of Energy adopted for its 2021 regulatory analyses. See: https://www.energy.gov/sites/default/files/2021-04/2021discountrates.pdf.

PSCA	$2,488,326	1.4%	$2,954,258	0.9%
HF	$4,088,063	2.2%	$15,051,505	4.6%
Corrective Action Program	$11,120,904	5.9%	$17,046,875	5.3%
All others	$17,231,716	9.1%	$29,490,535	9.1%
All	$189,548,879	100.0%	$324,395,884	100.0%
Annualized cost	**$23,571,924 - $40,341,231**			

CHAPTER 4: BENEFITS OF ADOPTED RULE

The refining industry has long been one of the most hazardous industries in the U.S. and across the world. According to the EPA, oil refineries had a higher frequency of serious incidents than any other industrial sector covered by its Risk Management Plan (RMP) rule during 2004-2013. OSHA also found that since the PSM standard was adopted in 1992, no other industry in the U.S. has had as many fatal or catastrophic incidents as the oil refining industry.

Major accidents on refinery sites have the potential to result in hundreds of millions of dollars of physical damage to the properties, present a catastrophic injuries, illnesses, and even deaths to employees and the population in nearby communities, and may lead to significant business interruptions. Nationwide, a significant number of recent refinery incidents have been catastrophic involving substantial property damage and economic loss for both the refinery and public, serious injuries and worker fatalities, health concerns and social disruption to surrounding communities, as well as environmental harms. Under the current regulatory regime, the refining industry in Washington State has had at least three incidents that could be considered as catastrophic based on the extent of social and economic harms they have caused.

The purpose of the original PSM standard was “preventing or minimizing the consequences of catastrophic releases of toxic, reactive, flammable, or explosive chemicals”. Where “Catastrophic Release” referred to “a major uncontrolled emission, fire, or explosion, involving one or more highly hazardous chemicals, that presents serious danger to employees in the workplace”. The adopted rule revises the purpose of the PSM standard for refineries to “reduce

the risk of refinery process safety incidents by eliminating or minimizing process safety hazards to which employees may be exposed". Process safety incident is defined in this new rule as "an event within or affecting a process that causes a fire, explosion or release of a hazardous chemical or material and has the potential to result in death or serious physical harm." The change of focus and the adopted new and expanded process safety elements represent a significantly more protective standard than the current rule. As a result, the adopted rule is expected to prevent various major refinery incidents (MRIs)[87] from happening, which will benefit the refineries and their workers, as well as the public in nearby communities.

4.1 Types of Benefits Considered

Refinery incidents can impact and impose significant costs on the industry, nearby communities and the environment, as well as the whole society. The costs of MRIs include:

- Fatalities to refinery workers and public in nearby communities
- Health care and other costs of injuries to workers and community members
- Damages to equipment and properties
- Evacuation costs (or shelter-in-place events)
- Fines and penalties from state and federal regulators
- Lawsuits and legal fees
- Emergency response costs
- Environmental harms of oil spills or other accidental leaks
- Consumer deadweight losses from the distorted fuel prices
- Post-incident recovery
- Costs to repair refinery local public image
- Increased worker's compensation and other insurance premiums
- Loss of production profits

[87] A process safety incident in Washington's adopted rule is equivalent to a "Major Refinery Incident" (MRI) defined in California's PSM rule § 5189.1. To avoid confusion with process safety information (PSI), we adopt MRI in our discussion of process safety incidents.

Some of these potential costs will not be analyzed due to the lack of data or reliable information. Others such as loss of profits are largely transfers from the affected refineries to others, so they will not be considered as part of cost savings from the MRIs. Nevertheless, they can still be costly to the refineries involved, and thus give refineries incentives to adopt the process safety requirements. Additionally, if the adopted rule improves the safety culture of refineries, then the industry may benefit from the improved labor-management relations and reduced employee turnover rates.

4.2 Types of Refinery Incidents

The types of incidents that have the greatest societal impacts do not occur often. That said, there is still a significant possibility of severe incidents occurring should the current status remain. To estimate the annual benefit of the adopted rule, it is useful to examine various types of refinery incidents that have happened so far in Washington as well as those that have occurred in other places and could happen here in the future. Generally speaking, there are three categories of incidents based on the level of severity:

- Relatively minor refinery incidents that result from process safety failures, occur with some regularity, and involve non-fatal work injuries and potentially other relatively small consequences;
- MRIs that typically involve significant property damage, worker injuries and deaths, and extensive shutdown, which have occurred multiple times under the current regulatory regime in Washington; and
- Most costly severe incidents that cost more than what have happened in Washington's refining industry. These incidents cost at least half a billion dollars in property damages and other losses. They are extremely rare events but still possible based on the history of such events in other states under similar regulatory regimes. Some examples of these events are listed in Appendix.

4.3 Costs of Major Refinery Incidents Occurred In Washington

4.3.1 Background of the MRIs

Although there are cost savings in everyday refinery operations from any avoided accidents, the most significant economic benefits will likely result from the prevention of large MRIs. For estimating the potential cost savings and other benefits, we review the history of major incidents in the state. The three largest refinery incidents occurred in Washington State in the last few decades were:

1. The 1998 Equilon Refinery incident in Anacortes, WA.
2. The 2010 Tesoro Refinery incident in Anacortes, WA.
3. The 2012 BP Cherry Point Refinery incident in Blaine, WA.

4.3.1.1 Equilon Refinery Incident

On November 23, 1998, a storm with high winds disrupted electrical power at the refinery for a period of two hours, interrupting normal refinery operations. The disruption in operations necessitated the restart of the refinery's delayed coking unit. On November 25, significant managerial decision errors as well as procedural errors made during the restart process led to an explosion and fire in the delayed coking unit that resulted in the deaths of six workers.[88] It was the worst industrial accident in the state since L&I began enforcing the Washington State Industrial Safety and Health Act (WISHA) in 1973 until the 2010 Tesoro refinery explosion. At the time of the 1998 incident, the refinery was operated by Equilon Enterprises, a joint venture between Shell and Texaco. The refinery is currently owned by HollyFrontier

4.3.1.2 Tesoro Refinery Incident

On April 2, 2010, the Tesoro Anacortes Refinery experienced a catastrophic rupture of a Heat Exchanger in the Catalytic Reformer / Naphtha Hydrotreater unit. The rupture resulted in a

[88] McClary, D.C. (2003), "Explosion and fire at the Equilon Puget Sound Refinery in Anacortes kill six refinery workers on November 25, 1998." HistoryLink.org Essay 5618, Nov. 20 2003. Available at: https://www.historylink.org/File/5618

release of hydrogen and naphtha which ignited causing an explosion and a fire that lasted over three hours. Seven employees were in the immediate vicinity of the explosion and suffered fatal injuries.[89] The fire explosion and subsequent investigation required the refinery to be shut down from April 2, 2010 to November 5, 2010. This was the state's worst industrial accident in 50 years.

4.3.1.3 BP Cherry Point Refinery Incident

On February 17, 2012, a recirculation pipeline of the Vacuum Tower in the Crude/Vacuum unit ruptured releasing hot vacuum residuum and resulted in a fire in the unit. In the subsequent investigation, the ruptured pipe was found to have significant thinning due to corrosion. The investigation revealed that BP's inspection practices were inconsistent with the RAGAGEP applying to piping in crude vacuum service. No workers or community members were directly injured in the incident. However, the release of hot vacuum residuum could have resulted in serious burns or death of workers exposed to the hazard. When BP attempted to restart the unit in early May, the hot crude oil continued to leak and smoke and they had to suspend the procedure for an extended period of time.[90]

4.3.2 Costs Associated with the MRIs

4.3.2.1 Value of Lives Lost from Refinery Incidents

Often the most significant societal cost of a refinery incident is the death of a worker or community member if that occurs. A reduction in the frequency of process safety incidents that involve worker or community member fatalities represents a significant source of potential benefits to the industry and the whole society as well. We estimate the likely benefits of reducing fatalities in future refinery incidents based on the historical record in Washington State. Specifically, we estimate the number of lost lives that could have been saved by the adopted rule based on the actual number of fatalities that have occurred under the current regulatory regime. The federal PSM standard was enacted in 1992 and various elements became effective in

[89] CSB, 2014, U.S. Chemical Safety and Hazard Investigation Board, Investigation Report: Catastrophic Rupture Of Heat Exchanger, Report 2010-08-I-WA, May 2014.
[90] L&I, 2012, "Citation Invoice, Inspection: 315812925." August 16, 2012.

subsequent years, and the federal EPA RMP standard was enacted in 1996. Thus, the year of 1996 serves as the starting point for the current regulatory regime.

The societal cost of each fatality is estimated using the Value of Statistical Life (VSL). This value has been discussed in many studies, most of which revealed an inverted-U relationship between age and VSL.[91] Given the mean and median age of 38 for all the workers killed in the fatal refinery incidents in the state, this analysis adopted the Aldy and Viscusi (2007)'s estimate of $9.85 million (2000 dollars) for the age group of 35 - 44 as the average value of each life lost in these incidents. Adjusted for inflation, this is equivalent to $17.43 million (2023 dollars). As described above, there were six fatalities from the 1998 Equilon Refinery incident and seven from the 2010 Tesoro incident. In addition, there was one fatality to then-Texaco refinery (now owned by HollyFrontier) in 1996.[92] Using the VSL estimated above, the total value of 14 lives lost in these incidents amounts to $244.02 million.

Beyond the VSL, worker deaths impact industry and society in other forms. First, the expertise and skill the workers possessed is lost and could be costly to replace. Second, such incidents will severely affect both worker moral and labor-manager relations for refineries. Third, the industrial incidents involving worker deaths, particularly those with multiple worker deaths, can have long-term impact on the families of victims and the nearby communities.

4.3.2.2 Property Damages from Refinery Incidents

When a major refinery incident occurs, it often causes substantial property and equipment damages and loss of production at that facility. An explosion or fire could also damage properties nearby including vehicles, homes or businesses. Given how expensive these fixed assets are and how closely these pieces of equipment are connected to each other, the total cost of repairing or

[91] Here are some of these studies: O'Brien (2018), Aldy and Smyth (2014), Evans and Smith (2008), Aldy and Viscusi (2008, 2007, 2003), Kniesner, Viscusi, and Ziliak (2006), Persson, et al. (2001), Johannesson, et al. (1997).
[92] Source: USW Local 12-591 website. In that incident, the worker was struck and killed by an exchanger cover which was blown by the pressure built up from a formed plug when the worker was trying to steam out the exchanger.

replacing all the damaged properties and equipment from a major incident can be hundreds of millions of dollars if not more.

No reliable sources were found to directly estimate the costs of the property damages and production losses from the three major incidents occurred in Washington, although they were expected to be very significant given the observed size of the physical damages and the resulting long disruptions from these incidents. Therefore, we conducted an extensive review of industry and government studies that contain reliable quantified information on the economic cost of the equipment and other asset damages from refinery incidents that are comparable to those occurred in Washington. Based on the review of existing literature, the property damages from a major refinery fire and explosion incident can cost a refiner anywhere from tens of millions of dollars to as high as a few billions of dollars. For example, a fire incident occurred at Exxon's Baton Rouge refinery in 1993 resulted in $78 million (2002 dollars) of property damage losses while a fire at a refinery in UAE in January 2017 cost more than $1.2 billion (2021 dollars). Table 4.1 presents a list of similar refinery fire and explosion incidents occurred in U.S. in the recent three decades, which shows these incidents cost in a range of $75 - $336 million in property damages.

Table 4.1: Comparable recent refinery fire/explosion incidents and cost of property damages[93]

Year	Refinery location	Cost (in millions, 2023 dollars)
2007	Pascagoula, MS	$347
2001	Carson, CA	$277
1999	Richmond, CA	$277
1997	Martinez, CA	$135
1995	Rouseville, PA	$77
1993	Baton Rouge, LA	$132
1992	Los Angeles, CA	$164
1989	Richmond CA	$274

[93] From multiple data sources including "Chemical Process Safety-Learning from case histories", Roy (2015) and "100 largest losses in the hydrocarbon industry", Marsh periodic reports.

Given the scale and aftermath of the fire/explosion, the duration of shutdown following the incident, and the level of investigations for Tesoro and Equilon incidents,[94] L&I estimates the cost of property damages in each of these two incidents to be $132 - $277 million.[95] This was equivalent to the $72 - $151 million for Equilon incident and $97 - $202 million for Tesoro incident in the year of 1998 and 2010 when they occurred. L&I also estimates the BP 2012 incident caused $51 - $107 million (2012 dollars), or $68 - $143 million (2023 dollars), in property and equipment losses given the size of damages and the shut-down duration from the fire.[96]

4.3.2.3 Legal Costs from Major Incidents

Many major refinery incidents also result in hefty costs in settlement payments to the family of fallen workers, legal and administrative expenses associated with the settlement, fines and penalties paid to the government regulators, etc. Although the fines and legal settlement are arguably transfer payments from the affected companies to the government and victim families involved, lawsuits always involve a variety of transaction costs and legal expenses that do represent economic costs. And a recent literature review by Polinsky and Shavell (2010) on legal and administrative expenses in the tort system provided estimates of these costs ranging from 43% - 63% of the amount settlement or judgement.[97] L&I adopted this range for the estimate of the non-transfer part of legal costs from the two fatal incidents occurred in Washington State.[98]

[94] The Equilon incident was the worst industry accident in Washington State since L&I began enforcing the Washington State Industrial Safety and Health Act (WISHA) in 1973 until 2010 when Tesoro incident occurred, which remains the state's worst industrial accident in 50 years. The explosion at Tesoro was so violent that many in Anacortes felt the shock wave across Fidalgo Bay. The whole refinery were closed for more than 7 months. Besides, CSB acknowledged that its investigation report for this incident was one of the most extensive and complex refinery explosion investigations it had conducted.

[95] This is the range of property damages from the incidents listed in the table, excluding the two with the highest and lowest costs.

[96] The duration of the facility closure by the incident was approximately 50% of that of Tesoro incident (102 days vs 217 days).

[97] Polinsky, A. M and S. Shavell, 2010. "The Uneasy Case for Product Liability," April 20, 2010, 123 Harv. L. Rev. 1437, Available at: https://harvardlawreview.org/2010/04/the-uneasy-case-for-product-liability/

[98] BP was cited for six serious violations and one willful violation with $81,500 (2012 dollars) in penalties. As the fines and penalties are considered transfer payments, this legal cost will not be counted in this section.

As a result of the explosion and associated deaths, Equilon agreed to a $4.4 million (1999 dollars) settlement package with the regulators, the largest monetary settlement ever reached as the result of worker safety and health investigation by then.[99] However, these costs are considered transfer payment, so they will not be counted as part of the societal cost of the incident. Equilon Enterprises also paid a $45 million settlement (in 2001 dollars, equivalent to $77.50 million in 2023 dollars) to the families of the six workers killed in the accident. Using the ratio of 43% - 63% described above, the legal and administrative expenses associated with this settlement were estimated to be $33.33 million - $48.83 million (2023 dollars).

For Tesoro incident, L& I investigated the incident for six months before issuing its final report. L& I found that the explosion had been entirely preventable, and cited Tesoro for 44 violations including 39 willful and 5 serious violations of workplace safety and health regulations. Lawsuits by the families of the seven fallen workers were settled for $39 million (in 2013 dollars, equivalent to $51.04 million in 2023 dollars).[100] Using the same ratio as for Equilon incident, the non-transfer part of legal and administrative expenses of this incident would amount to $21.95 million - $32.16 million (2023 dollars).

4.3.2.4 Consumer Deadweight Loss from Gas Price Distortion

A deadweight loss is a societal cost created by market inefficiency, which occurs when supply and demand are out of equilibrium and the optimal outcome is not achieved. When a major refinery incident occurs, it often results in partial or complete shutdown of the plant. Such an event causes considerable gas price increases in local markets and significantly impacts consumers, including the so-called deadweight loss from this price distortion. The magnitude of

[99] See McClary, 2003. As part of the package, Equilon paid $1.1 million to the State of Washington for worker safety violations. It paid $1 million to the Fallen Worker Scholarship Fund, which was established on behalf of families of Equilon refinery workers. One million dollars was allocated to the creation of a Workplace Safety and Health Institute, while $350,000 was paid to the Anacortes Fire Department for the purchase of a new firetruck and another $350,000 was paid to hire an independent consultant to conduct an audit of the refinery's safety practices

[100] Shotwell (2014), "Tesoro explosion caused by safety and equipment flaws," Anacortes Now, Jan. 30, 2014, available at: https://www.anacortesnow.com/news/community-news/2692-tesoro-explosion-caused-by-safety-and-equipment-flaws.

the impact depends on which process units are idled and for how long as a result of the incident. When a critical gasoline production unit such as the fluid catalytic cracking goes offline, a refinery's ability to produce gasoline can be impeded even if other process units remain operable. Integration of major refinery units often means that the shutdown of one unit can result in reduced production at other units. The impact also depends on the time of the year: refiners' fuel blends vary with season as does the demand for transportation fuels. In summer, when gasoline demand is at its peak there is little excess refining capacity available to tap in the event of a shutdown.[101] Table 4.2 below shows the durations of shut-down for two major refinery incidents that occurred in Washington compared to those in California. Although Washington is in the same fuels region as California, its fuel markets differ in significant ways. Some of the differences are, that Washington has less restrictive fuel blend requirements, has significant excess refining capacity, and is connected to other production regions via pipelines.

Table 4.2: Comparison of California and Washington MRI disruptions

Events	Start Date	End Date	Length in Days	Data Source
Tesoro Anacortes Refinery, WA	4/2/2010	11/5/2010	217	OGJ, 11/05/10
BP Cherry Point, WA	2/17/2012	5/29/2012	102	Reuters, 05/29/12
Chevron Richmond, CA	8/12/2012	4/25/2013	256	Rand , 2016
ExxonMobil Torrance, CA	2/18/2015	5/10/2016	447	OGJ, 05/11/16

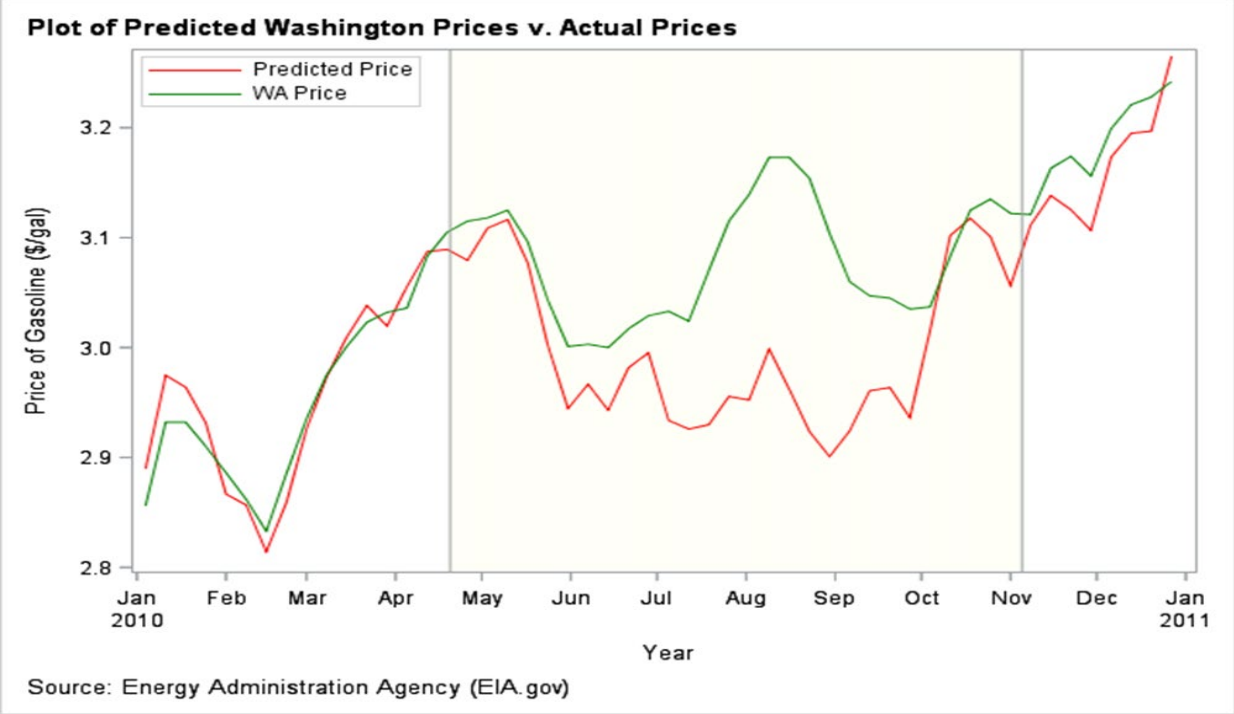
Following a similar approach to Rand (2016), L&I used historical data on average retail fuel prices in Washington State and in the United States to estimate the cost to consumers of the price increases resulting from the major refinery incidents. Weekly average fuel price data for Washington and the U.S. was collected from the U.S. Energy Information Administration (EIA) for January 2007 to December 2012.[102] Washington price data was removed for the weeks of the

[101] EIA, 2007. United States Energy Information Agency, "Refinery Outages: Description and Potential Impact on Petroleum Product Prices." March 2007, Available at: https://www.eia.gov/analysis/requests/2007/SROOG200701.pdf (Accessed January 17, 2019).
[102]Necessary data was not available for the Equilon incident. The price for this period were significantly affected by the Great Recession and lasting impacts.

Tesoro Anacortes shutdown and the BP Cherry Point shutdown. Therefore, a regression of Washington weekly retail prices on U.S. average retail prices was used to predict counterfactual prices during the shutdown periods.

For Tesoro Refinery shutdown, L&I estimated its gas price impact using the weekly price data for the period of 2007-2011. The model R-squared was 0.98, indicating the model explained 98% of the variation in Washington weekly gasoline prices. Figure 4.1 plots the estimated price impact during the Tesoro outage. The area between the WA price series and predicted Price series during the shutdown period measures the direct cost paid by consumers.

Figure 4.1: Projected Gas Price Impact from Tesoro explosion



Using the methodology described in Chapter 7: Appendix, A.1, L&I estimates that Tesoro shutdown increased gasoline prices by an average of $0.08, or approximately 3%, per gallon during the period it was shut down, with a maximum price impact of $0.23 per gallon. To estimate the weekly cost to consumers, the estimated weekly price impact was multiplied by the

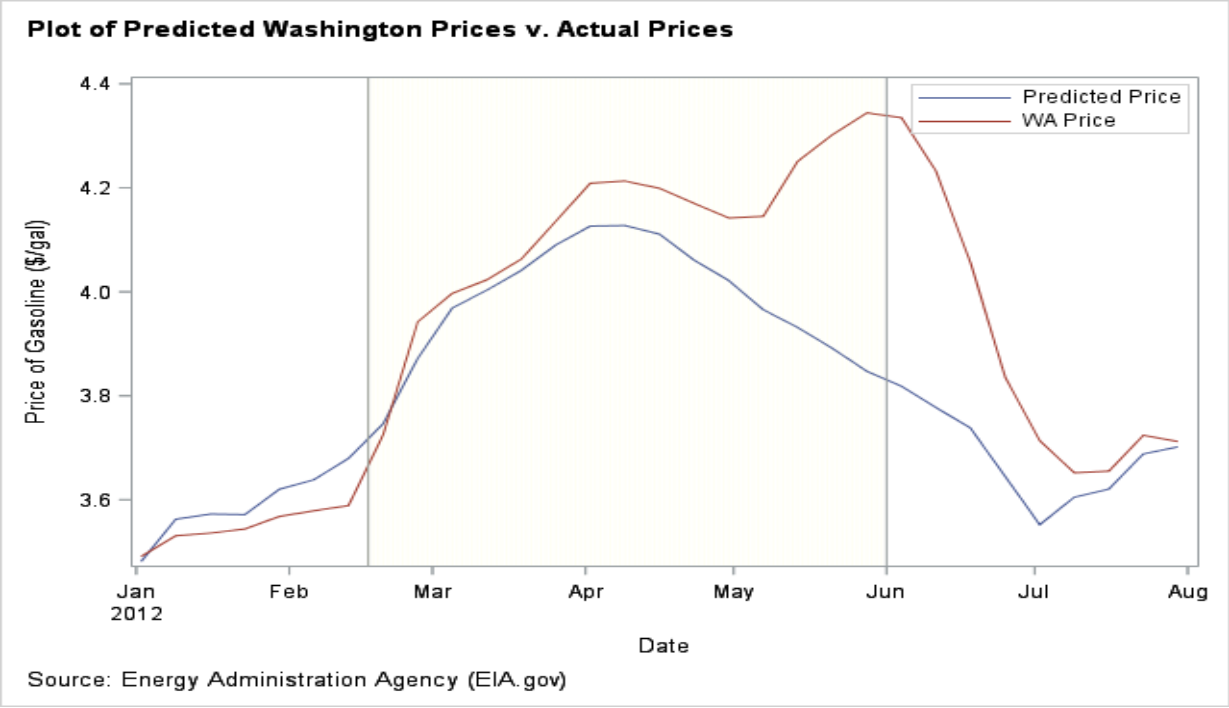
weekly statewide total sales.[103] L&I estimated that the direct impact of increased motor fuel prices was an additional $128 million of cost to consumers ($173.19 million in 2023 dollars). As previously noted, the extra cost born by consumers would be transferred to refineries as increased profits.

In addition to the direct impact on consumers, there was an indirect impact of a reduction in purchases due to the increased price. It was assumed that consumer's short run elasticity of fuel is -0.07,[104] meaning that consumers will respond to a 10% gas price increase by reducing total purchases by 0.7% over a relatively short time period. Using the estimated price increase and the resulting reduction in gas sales in each week,[105] the total deadweight loss to the society is estimated to be $210 thousand from this incident. Assuming an equivalent impact in diesel and jet fuel markets would approximately double the impact, [106] yielding a total deadweight loss of $420 thousand (2010 dollars), or $590 thousand (2023 dollars).

Similarly, L&I estimated the impact of the BP Cherry Point shutdown using the weekly price data for the period from the beginning of 2007 to August of 2012.[107] In mid-May 2012, gasoline inventories in the PADD V region hit their lowest level since March 1999, and the BP shutdown was expected to be a big contributor to that. As a result of the shutdown and record low inventories price remained elevated for several months beyond the end of the shutdown (see Figure 4.2).

[103] Data Source: EIA.gov.
[104] Coyle, D., J. DeBacker & R. Prisinzano, (2012),"Estimating the supply and demand of gasoline using tax data," Energy Economics 34 (2012) pp.195-200.
[105] Gas sales fell by an average of 100,000 gallons below what they would have been absent the shock per week, or approximately 3 million gallons over the entire shut-down period.
[106] The Department of Commerce used long-run elasticities of -0.61 for motor gasoline, -0.44 for distillate fuel oil, and -0.23 for jet fuel, suggesting that demand for diesel and jet fuel are much less elastic. WA Department of Commerce (2018), "Carbon Tax Analysis Model (CTAM), version 4.0 base case", Nov 11, 2019. Available at: https://www.commerce.wa.gov/growing-the-economy/energy/washington-state-energy-office/carbon-tax/.
[107] Because Washington prices are consistently well above U.S. average prices and remained elevated for some time after the shutdown ended, it is difficult to determine the exact endpoint of the price impact. We calculated a range for the price impacts with the low value estimating the impact from the start of the shutdown until the restart of the refinery (May 29), while the high value estimates the impact through August 1, 2012. We chose August 2012 due to the additional disruption to fuel market created by the Chevron Richmond incident.

Figure 4.2: Projected Gas Price Impact from BP Fire



Using the same method, L&I estimated that price increased by an average of $0.14 - $0.16, and as high as $0.52 at certain time. The direct cost to consumers of the shutdown was $107 - $202 million, and the deadweight loss was $290 thousand - $610 thousand. Based on the same assumption for diesel and jet fuel markets, the total deadweight loss would amount to $580 thousand - $1.22 million (2012 dollars), or $774 thousand to $1.63 million (2023 dollars).

Table 4.3: Price impacts of Tesoro and BP refinery shutdowns[108]

Factor	Tesoro	BP
Average gasoline price increase ($/gallon)	0.08	0.14 - 0.16
Maximum gasoline price increase ($/gallon)	0.23	0.50 - 0.52
Reduction in total purchases of gasoline (million gallons)	3.0	1.9 – 3.7
Total deadweight loss from gas consumptions (million $ in original year)	0.21	0.29 - 0.61
Total deadweight loss from all consumptions (million $ in original year)	0.42	0.58 - 1.22
Total deadweight loss from all consumptions (million $ in 2023 dollars)	0.59	0.77 - 1.63

4.3.2.5 Profit Losses Associated With MRIs.

Major refinery incidents (MRIs) often cause a shut-down of the affected equipment or even the entire plant, leading to a sharp decline in production and profits of the affected refineries. But because of the economic structure of the refining industry, lost production profits are largely transferred to other refiners that continue to produce. Therefore, the lost production profits estimated below are excluded from the total costs of these incidents. Nevertheless, L&I provides this information as the impact could still be very significant, sometimes even catastrophic, to the affected refiners, so this analysis may be interesting to the businesses and the industry as a whole. Due to the data limitation, this section only analyzes the profit losses from the Tesoro and BP incidents.

As a result of the refinery explosion and subsequent investigation, Tesoro Anacortes shut down operations on April 2, 2010 and did not fully restart operations until November 5, 2010, with the affected period of 217 days.[109] Using the average price of the products and a 7% profit margin,[110] L&I estimates the value of lost production from Tesoro incident to be approximately $155.68 million (2010 dollars), or $218.29 million (2023 dollars).

[108] Data were not available to estimate the price impacts of Equilon incident. Given its similarity to the Tesoro incident in the level of damages, L&I will also use $0.56 million as the deadweight loss from this incident.
[109] OGJ editors (2010), "Tesoro restarts Anacortes refinery, appeals Citations," Oil & Gas Journal, Nov. 5 2010.
[110] Gonzales et al (2016).

For BP incident, the refinery was shut down on February 12, 2012 due to the fire in its crude distillation unit. BP took advantage of the shutdown to undergo maintenance that was planned for later in the year in order to minimized downtime. The refinery did not resume full operations until May 29, 2012.[111] We estimate the value of lost production during the period to be approximately $182.52 million (2012 dollars), or $243.53 million (2023 dollars).

Table 4.4: Lost production profits from Tesoro and BP Incidents

Factor	Tesoro	BP
Capacity (million gallons/day)	5.25	9.83
Days of shutdown	217	102
Lost production (million gallons of crude input)	1,139.25	1,002.46
Average price at the year	$2.27	$3.06
Ratio of output of 3 products to crude input	0.86	0.85
Lost revenue (million dollars)	$2,224.04	$2,607.39
Profit margin	0.07	0.07
Lost profit (million in 2010 dollars)	$155.68	$182.52
Lost profit (million in 2023 dollars)	$218.29	$243.35

Refiners usually purchase business interruption (BI) insurance, and those that have experienced explosions or fires in the past usually see their costs of insurance double or even higher. Some companies in turn could respond by purchasing less coverage, thereby exposing themselves to a greater financial risk. These trends may represent millions of dollars of additional insurance costs annually as well as increased liability if they choose to reduce coverage.

[111] Reuters, 2012.

4.4 Cost Savings from Potential Avoidance of Most Costly Events

Several extreme events costing refineries more than $500 million of losses have occurred in recent years. For example, the insured losses resulting from the 2019 explosion at Girard Point Refinery in Philadelphia were estimated to be as high as $1.25 billion;[112] while the Marsh Report estimated that the property damage along with debris removal and clean-up costs totaled $750 million (2019 dollars).[113] An earlier refinery explosion at the BP Texas City plant cost the company around $1 billion dollars for facility repairs and other losses. (Bergin. T, 2008).

Based on the review of Marsh reports of the 100 largest losses in the hydrocarbon industry and CSB reports of major refinery incidents, L&I identified at least five refinery fires and explosions between 2001 and 2019 that qualify for the "most costly" events.[114] Given the average of 139 operable refineries in U.S. during this period,[115] the probability of such costly event occurrences is approximately 0.19% for each refinery in each year. Assuming Washington refineries are consistent with this industry average incident rate, and based on the cost of $500 million - $1.25 billion per incident (2019 USD), the prevention of this type of incidents could create annual savings of $4.94 million - $13.72 million (2023 dollars) .

Table 4.5: The most costly refinery fire & explosion incidents in U.S. in recent years

Date of Event	Location	Incident description
8/14/2001	Lemont, IL	The refinery was shut down due to a pool fire caused by incorrect piping material specification in one elbow, which failed and led to a pipework release on the crude distillation unit. Three days later, the crude column suffered a structural failure due to an internal fire caused by air ingress from the previously ruptured pipework reacting with pyrophoric material and oil in the column. The CDU was shut down for 12 months.

[112] Insurance Journal, 2020.
[113] Marsh JLT Specialty, 2020.
[114] Two refinery incidents that cost more than $500 million were excluded due to the fact that they were caused by hurricanes, which we don't think they would likely occur in Washington. A few other major refinery fires & explosions occurred during this time frame were also excluded due to the lack of reliable cost information.
[115] EIA: https://www.eia.gov/petroleum/refinerycapacity/archive/.

3/23/2005	Texas City, TX	Loss of control of the restart of the isomerization unit resulted in one of the unit's splitter columns becoming full of light hydrocarbon. Eventually, hot liquid was released from the column through relief valves to a 30-meter-high blowdown stack on the unit. The release generated a large vapor cloud in the unit's vicinity, which found a source of ignition and exploded. A total of 15 people were killed and 180 injured following the explosion.
2/18/2008	Big Spring, TX	An explosion at this refinery caused damage to the fluid catalytic cracker (FCC) utilities, storage tanks, and asphalt unit. The release is believed to have occurred during a start-up on the propylene splitter unit, as a result of the catastrophic failure of a pump. The refinery experienced two months of shutdown and took 8 months to reach full production.
4/26/2018	Superior, WI	An explosion and subsequent fire at the refinery resulted in injuries to 36 people, and the evacuation of a large portion of the nearby town. The incident occurred when the site fluid catalytic cracking unit (FCC) was taken offline for planned maintenance. It is believed that the FCC spent catalyst slide valve had eroded and failed to maintain the catalyst level required to prevent air from mixing with hydrocarbons during the transient operation. As a result, air flowed backwards from the regenerator into the reactor and other downstream equipment, triggering a large explosion. The explosion blew debris across the plant and one piece punctured a nearby large storage tank, causing the release of 15,000 barrels of hot asphalt that subsequently ignited and set a large fire.
6/21/2019	Philadelphia, PA	A major loss of containment of process fluid, primarily propane, and hydrofluoric acid (HF) on the refinery HF alkylation unit resulted in a large fire and subsequent explosions. It is believed that the rupture of a thinned pipe elbow installed in early 1970s caused the process fluid release. The pipe elbow reportedly met the metallurgy requirements at the time of installation; however, it did not meet the intent of the updated American Society for Testing and Materials recommendations made in 1990s. The refinery closed shortly after the incident and eventually filed for bankruptcy.

4.5 Cost Savings from Nonfatal Worker Injuries

Another potential benefit of the PSM rule is the prevention of nonfatal injuries from the "relatively minor refinery incidents" defined in Section 4.2. The costs associated with these injuries were estimated using L&I's internal database on workers' compensation claims associated with refineries. Although the adopted rule may contribute to reducing injuries that are not process safety related, the explicit purpose of the rule is to eliminate or minimize process safety hazards to which employees may be exposed. L&I examined the accident source and accident type of each claim to narrow down to those process safety related claims that could have been prevented by the adopted rule. For example, the types of accidents that are most likely related to process safety are those involving a fire, explosion, or release of a hazardous chemical or material. From the accident source perspective, the process safety related accidents are most likely from chemicals, steam, vapors, or from pressurized containers. Using these criteria, L&I identified that out of an average of 112 claims from the five Washington refineries each year, approximately 24% - 29% of these claims are likely process safety related, which translates into an average of 27 - 32 claims each year for the whole industry.[116]

Given that the majority of Washington refineries are self-insured and are not required to report claim expenditures to L&I, the cost data from these self-insured refineries are inaccurate and cannot be used as the basis for determining average claim cost. L&I used the average claim cost of $36,427 from the state-fund refinery claims as the per-claim cost for all the process safety injuries and illnesses that could be prevented by the adopted rule. Based on the indirect-to-direct cost ratio of 110%, the average nonfatal claim cost is $76,497. Therefore the total nonfatal claim cost amounts to $2.07 million - $2.45 million per year for the whole industry.

[116] The number of process safety related claims from those with unknown accident type or accident source is extrapolated by applying the percentage of process safety related claims from those with known accident type or source information.

4.6 Cost Reduction of Environmental Harm

Additional cost-savings may result from preventing incidents that affect the environments proximate to the refineries. For Washington State, some of the potential areas that significant oil spills or leaks of other toxic substances from refineries may affect include unique and sensitive marine ecosystems and nearshore habitat areas that support all manner of wildlife, including endangered wildlife."[117] Several of the refineries are located on or immediately adjacent to these areas. Specifically:

- All five Washington refineries are located on the shores of the Salish Sea which is one of the world's largest and most biologically rich inland seas and the home for an estimated 37 species of mammals, 172 species of birds, 247 species of fish, and more than 3,000 species of invertebrates.[118] In addition, all refineries except Tacoma one are in close proximity to the San Juan Islands National Monument, the San Juan Islands National Wildlife Refuge, and numerous national, state, and local parks and conservation lands.
- The Shell Puget Sound and Marathon refineries are adjacent to the Fidalgo Bay Aquatic Reserve and the Padilla Bay National Estuarine Research Reserve, while the BP Cherry Point and Phillips 66 refineries are adjacent to the Cherry Point Aquatic Reserve. The Padilla Bay National Estuarine Research Reserve contains the second largest eel grass meadow along North America's Pacific Coast. The meadow is a nursery for juvenile salmon, crab, herring, and the Bay also provides critical habitat for waterfowl and marine birds.[119]
- Fidalgo Bay in Skagit County and Cherry Point in Whatcom County are Washington Department of Natural Resources Aquatic Reserves established to conserve and enhance valuable native ecosystems, significant species, and important habitats on state-owned aquatic lands.[120]

[117] BlueGreen Alliance (BGA), "Letter on economic analysis of draft PSM adopted rule," February 13, 2020.
[118] Gaydos, J. K. and Brown, N.A. (2011). "Species of Concern within the Salish Sea: Changes from 2002 to 2011." Proceedings of the 2011 Salish Sea Ecosystem Conference, October 25-27, 2011, Vancouver, BC.
[119] Washington Department of Ecology, Padilla Bay National Estaurine Research Reserve. https://ecology.wa.gov/Water-Shorelines/Shoreline-coastal-management/Padilla-Bay-reserve.
[120] Washington Department of Natural Resources, Aquatic Reserves. https://www.dnr.wa.gov/managedlands/

- The March Point Great Blue Heron colony is one of the largest in Western North America. There are few remaining sites in Skagit County that are adequate for the nesting and foraging needs of Great Blue Herons. This makes protecting the March Point heronry critical for Skagit County and the state as a whole. If a refinery incident occurred during the nesting season, it could cause the herons to abandon the colony.[121] [122] [123]

According to the U.S. Energy Information Administration (EIA), the average refinery in the region maintains crude inventories of approximately 900 thousand barrels (37.8 million gallons).[124] The refineries also store inventories of finished fuels, feedstock inputs, and other hazardous chemicals onsite. Given the large amount of inventories, the potential environmental harm could be very significant if a spill or leak occurs.

4.6.1 History of Spills in Washington

There have been several accidents in oil spills or leaks of other toxic chemical compounds from Washington refineries in the past few years. Below are some of these incidents:

- Four oil spills occurred at Texaco's Anacortes Refinery (currently the Shell Puget Sound Refinery) facility between February 22, 1991 and March 25, 1992. The largest spill occurred during a ship off-loading operation on February 22, 1991 when a pump housing failure resulted in a release of approximately 5,000 barrels of crude oil. Although most of the crude was captured in a catch basin, 2,000 barrels were discharged onshore and 550 barrels made it into Fidalgo Bay. The spill resulted in the oiling of several intertidal

aquatic-reserves; https://www.dnr.wa.gov/managed-lands/aquatic-reserves/fidalgo-bay-aquaticreserve; https://www.dnr.wa.gov/managed-lands/aquatic-reserves/cherry-point-aquatic-reserve.
[121] Washington Department of Fish and Wildlife. Management Recommendations for Washington's Priority Species - Volume IV: Birds, (2012). Chapter 3. Great Blue Herons. Available at: https://wdfw.wa.gov/sites/default/files/publications/00026/wdfw00026.pdf. See also, Eissinger, A.M. 2007.
[122] Great Blue Herons in Puget Sound. Puget Sound Nearshore Partnership Report No. 2007-06. Published by Seattle District, U.S. Army Corps of Engineers, Seattle, Washington. Available at: http://www.pugetsoundnearshore.org/technical_papers/herons.pdf.
[123] BlueGreen Alliance (BGA), "Letter on economic analysis of draft PSM adopted rule," February 13, 2020.
[124] EIA, "Working and Net Available Shell Storage Capacity," May 29, 2020, https://www.eia.gov/petroleum/storagecapacity/.

habitats including: salt marsh, eelgrass, mud flats, mixed cobble beaches, boulders, rip-rap and pilings.[125]

- An unknown quantity of heavy fuel oil and jet fuel was spilled on August 5, 1997 from the Tosco Refinery (now Phillips 66) in Ferndale, Washington.[126]
- In March 2014, Anacortes Shell refinery reported a crude oil spill in its waste-water treatment plant due to a hose that broke during the transfer process. Refinery personnel and crews from the Coast Guard and Ecology responded to the scene and confirmed the spill was completely contained. The crude oil spill had the potential to be up to 8,000 gallons.[127]
- In February 2015, the Shell Puget Sound refinery accidently released un-combusted toxic vapors during a maintenance activity. It caused the release of about 700 pounds of un-combusted air pollutants including hydrogen sulfide, dimethyl sulfide, mercaptans, pyrophoric iron, and benzene. The release lasted about 3.5 hours and the released chemicals were carried by winds to the Swinomish Reservation and La Conner, WA. More than 550 people in these areas were impacted by the release and some sought medical attention.[128]
- A hydrofluoric acid leak from the alkylation unit at Phillips 66's Ferndale refinery in 2017 resulted in seven workers being hospitalized for the treatment. Six were released hours after being admitted, while the seventh remained hospitalized for 7 days.[129]

Nationally, the API estimated that between 1998 and 2007, an average of 12,136 barrels of oil were spilled each year from all U.S. refineries.[130] Assuming Washington refineries have a

[125] U.S. Department of the Interior, Natural Resource Damage Assessment and Restoration Program: Texaco Refinery Oil Spills, https://www.cerc.usgs.gov/orda_docs/CaseDetails?ID=968.
[126] U.S. National Oceanic and Atmospheric Administration (NOAA), "Noaa-Raw Incident Data," Available at https://incidentnews.noaa.gov/raw/index.
[127] "Anacortes Shell Refinery Oil Spill," Washington State Department of Ecology, March 2014.
[128] "EPA penalizes Shell for Anacortes refinery release," EPA news release, February 10, 2021.
[129] "One worker remains hospitalized from Phillips 66 Ferndale leak," Reuters, February 11, 2017.
[130] API, 2009 "Analysis of U.S. Oil Spillage," API PUBLICATION 356, August 2009

similar incident rate as the U.S. average and given Washington refineries' 3.68% of share of U.S. total operating capacity,[131] refinery spillage in Washington could occur at 446 barrels each year.

4.6.2 Cost of Potential Spills or Leaks

A recent report by Earth Economics has estimated the potential economic consequences of an oil spill occurring in the Haro Strait, west of the San Juan Islands of Washington State. The study considered two primary oil spill scenarios: a spill of 95,000 barrels of diluted bitumen and a spill of 24,000 barrels of heavy fuel oil.[132] It estimated economic costs for the scenarios for the following sectors: 1) commercial fishing, 2) aquaculture 3) tourist activity 4) property values and associated taxes, 5) recreational use value, and 6) ecosystem services. It estimated that the larger spill scenario would result in economic costs of $142.3 million - $509.9 million while the less severe scenario would result in economics losses of $84.3 million - $243.2 million (all in 2019 dollars). It is worth noting that the report indicated that "these damage estimates (including the upper bound of estimate ranges) should be considered underestimates, due to the conservative approach taken to estimate impact rates (in general, the average of the full range of observed impact rates/durations was taken as the upper bound of our estimates) and the exclusion of multiple impact categories that could not be integrated into this assessment due to data, methodology, and/or resource limitations, including: marine transportation, science and education, endangered species (such as the Southern Resident Killer Whales), human health, social services and cultural value." It further noted that "the indigenous right of Coast Salish peoples to hunt, gather shellfish and fish within the San Juan Islands and its surrounding waters was expressly reserved in the 1855 Treaty of Point Elliot, even without creation of a specific Indian Reservation on the islands. Today, the tribes who were signatories to that treaty continue to hold treaty rights within San Juan County, including rights to fishing, gathering shellfish and hunting. Loss of access to traditional tribal fishing and gathering areas within the County, due to an oil spill, results in deprivation of rights in violation of the treaty. Placing a dollar value on important cultural activities and resources can be controversial. The cultural value tribal

[131] EIA: Number and Capacity of Operable Petroleum Refineries by PAD District and State as of January 1, 2021.
[132] Page, R., Van Deren, M., Soares, J., Kerr, N. 2019. San Juan County Oil Spill Risk Consequences Assessment. Earth Economics, Tacoma, WA

communities place on ecosystems is far beyond economic measure; and there is no replacement for the loss of treaty rights. Therefore, this assessment does not take into account oil spill impacts to tribal resources. Due to this omission, the estimates presented in this report greatly underestimate the full impact of an oil spill in San Juan County waters."

Although the worst case scenario type event is rare, it is not uncommon that a refinery fire or explosion, or other major accidents, could lead to severe oil spills. For example, a refinery explosion in Superior, Wisconsin unleashed 2.1 million gallons of oil close to the shore of the Lake Superior.

The three major refinery incidents occurred in Washington did cause serious concerns about the air and water pollution. For example, when BP Cherry Point Refinery fire occurred in 2012, WA Department of Ecology (Ecology), EPA, and U.S. Coast Guard quickly responded to monitor and assess environmental impacts and a unified command involving all the parties in the response was established at the refinery. Although it was finally determined that no oil or polluted runoff had reached Washington waters, and all water and other materials used to fight the fire were contained within the refinery, Ecology and EPA officials remained at the site to assess and monitor potential environmental problems where it was treated in the facility's on-site wastewater treatment system. EPA contractors also continued taking air samples around the perimeter and downwind of the facility.

Although few severe oil spills or leaks have occurred in Washington in the recent years, they have occurred more often at similar refineries in other states. In addition, given the fact that most Washington refineries are located next to major body of water, it will be extremely costly if a large oil spill occurs. Based on all these considerations, L&I estimates the adopted rule would prevent at least one oil spill that would significantly affect the environment over 10 years and the scale of the incident could be anywhere from the less severe spill to a much larger spill described

in the report by Earth Economics. Therefore, the cost savings is estimated to be $10.04 million - $60.75 million annually.[133]

Table 4.6: Cost Savings from Preventing Catastrophic Incidents to Marine Environment

Cost savings of preventing one major oil spill over 10 years (in 2023 million dollars)	$100.44 - $607.52
Annual cost savings of spill preventions (in 2023 million dollars)	$10.04 - $60.75

4.7 Effectiveness of Adopted Rule

Reviewing the investigation reports on the causes of the three MRIs analyzed in Section 4.3, L&I is confident that the adopted rule addresses the root causes of each. L&I also believes that if strictly followed, the adopted rule may prevent more incidents that have occurred at similar refineries in other states but have not occurred in Washington so far. While it is impossible to separate the overall effectiveness of this adopted rule by each component, many key amendments in this adoption such as the expanded scope of the rule and the new safety elements required in HCA, SPA, DMR, and PSCA provisions are expected to help fill the safety gap and provide multiple layers of protection to eliminate the hazards that may lead to a MRI. Below are some of the key contributors to the overall process safety improvement.

4.7.1 HCA requirement

A 2011 study reviewed 63 reports, studies, and bulletins produced by the U.S. Chemical Safety Board (CSB) with the intent of identifying examples related to risk reduction measures from the hierarchy of safety controls. Although the study did not focus exclusively on petroleum refineries, several refinery, petrochemical, and energy production incidents were included in the

[133] L&I believes this is a conservative estimate as the cost basis from the report referenced above omitted a number of significant impact categories including marine transportation, science and education, endangered species, human health, social services, and cultural value. In addition, the cost impact of oil spills that report estimated was for San Juan County only instead of all affected areas across the state.

sample. The examples were analyzed for their contribution to incident prevention and their effect on the severity of consequences. The researchers identified 258 examples relating to the hierarchy of controls: 36% of examples related to inherent safety, 8% related to passive engineered safety, 14 % related to active engineered safety, and 42% related to procedural safety. Of the examples identified approximately 70% were related to prevention efforts while 30% were related to mitigation of consequence.[134] These results suggested a key role for HCA and inherently safer technology in prevention and mitigation of accidents.

CSB reports from recent incidents provide further insights. For example, its report following the Tesoro incident investigation summarized that the catastrophic rupture of the heat exchanger in Tesoro's Catalytic Reformer unit resulted from High Temperature Hydrogen Attack (HTHA), a damage mechanism that can severely degrade the mechanical properties of steel. CSB indicated that HTHA is difficult to detect by inspection and the use of an inherently safer material would have prevented the equipment rupture that resulted in a fire and explosion.[135] Many components in the HCA section of the adopted rule, including the requirement of identifying, analyzing, and documenting all inherent safety measures and safeguards for each process safety hazard in the priority order, are expected to contribute to the prevention of this type of incidents.

4.7.2 Safeguard Protection Analyses (SPA) requirement

In its regulatory findings for the Tesoro Anacortes incident, the CSB report indicated that an additional weakness of the current Washington PSM standard is that it does not require facilities to analyze and document the effectiveness of safeguards identified in Process Hazard Analyses (PHAs); if it did, Tesoro and the previous refinery owner, Shell Oil, would have been obligated to evaluate and document the effectiveness of safeguards rather than relying on qualitative safeguards to prevent equipment failure.[136] The adopted SPA requirement under WAC 296-67-

[134] Amyotte, P.R., D.K. MacDonald, F. I. Khan, 2011. "An Analysis of CSB Investigation Reports Concerning the Hierarchy of Controls," Process Safety Progress, Vol 30(3) Sept. 2011 Pp. 261-265.
[135] CSB, 2014, p. 12.
[136] CSB, 2014.

323(2)(a) that requires SPAs identify the most protective safeguards would have filled this gap and substantially reduced the likelihood of this event occurrence.

4.7.3 Damage Mechanism Reviews (DMRs) requirement

DMRs are instrumental in establishing and maintaining an effective Mechanical Integrity program and play several important roles in other PSM elements, including: 1) selecting appropriate equipment inspection intervals, locations and techniques; 2) making decisions such as modifications to a process, materials selection, and monitoring frequencies that can reduce the probability of a specific damage mechanism; and 3) determining the types of failures that could occur."[137] DMR is a critical new component of PSM rule that will contribute to the safety of refining operation and protection for affected workers.

As an example, the 2012 BP Cherry Point incident was initiated by a pipe rupture resulting from sulfidation corrosion, which can cause thinning to the point of pipe failure when not properly monitored and controlled.[138] The adopted DMR requirement will help refiners effectively identify the piping damage mechanisms, address the issues, and eliminate the hazards before a major incident happens.

4.7.4 Process Safety Culture Assessment (PSCA) Requirement

The Tesoro Martinez Refinery in California had two separate incidents of sulfuric acid release in the alkylation unit in 2014. The first incident involved the release of approximately 84,000 pounds of sulfuric acid which burned two workers performing maintenance on the unit and prevented them from returning to work for over 150 days each. In the second incident, two contract workers were sprayed with sulfuric acid. The CSB identified numerous process safety management system deficiencies in its investigations at the refinery that were causal to the incidents (CSB 2016). The CSB found that specific safety culture weaknesses at the refinery

[137] (Rehmat et al, 2017).
[138] (CSB, 2013 p.13).

demonstrated by a history of alkylation unit sulfuric acid incidents, failure to learn from past incidents and implement important safety lessons, weak management commitment to robust practices and procedures, and tolerance of worker exposure to unsafe conditions, all contributed to both incidents. Similar situations existed in the three Washington refineries that experienced MRIs, and the adopted PSCA requirement in this new rule will help refineries build a strong foundation of safe operations facility-wide.

4.8 Total Estimated Benefits

Based on the benefit analyses in each section above, the total quantifiable annual benefit of the adopted rule is estimated to be $40.74 million - $114.49 million.

Table 4.7: Total estimated benefits of the adopted rule (in 2023 million dollars)

Description	Low	High
Annual average cost of MRIs	$24.36	$39.42
Annual Cost savings of spill prevention	$10.04	$60.75
Annual Cost savings from prevented nonfatal injuries	$2.07	$2.45
Annual expected cost of "most costly" incidents	$4.94	$13.72
Total annual cost saving of adopted rule	**$41.41**	**$116.34**

CHAPTER 5: COST BENEFIT DETERMINATION

As analyzed in the previous two sections, the total probable costs of the adopted rule are estimated to be $23.57 million - $40.34 million each year, while the total quantifiable annual benefits range from $41.41 - $116.34 million. There are other benefits of the rule that impact societal well-being but are difficult to quantify.

Based on these quantified results, it is most likely that the probable benefits of the rule will outweigh the probable costs. While the uncertainties in these estimates are high, L&I believes this conclusion is reasonably drawn based on all the available information and its best understanding of the impact of the rule at the time of the writing of this report.

CHAPTER 6: LEAST BURDENSOME ANALYSIS

L&I must determine whether a rule being adopted is the least burdensome of the alternative requirements that still achieves the goals and objectives of the authorizing statutes.[139] The authorizing statute is the WISHA, and its goals and objectives are to assure, as may reasonably be possible, safe and healthful working conditions for every person working in the state of Washington[140]. L&I assessed the alternatives to elements of the adopted rules, and determined whether they met these goals and objectives. Of those that met the goals and objectives, L&I determined that the adopted rules were the least burdensome version of the rule for those who are required to comply, given the goals and objectives of the law.

The Department of Labor & Industries (L&I) explored two alternative pathways – maintaining the status quo and implementing the safety case model:

7.1 Maintain status quo:

One alternative considered was continued enforcement of petroleum refineries under the existing PSM regulation without revising the requirements. The United States Department of Labor, Occupational Safety and Health Administration's (OSHA) PSM standard is over 20 years old. L&I began enforcing the Washington State Industrial Safety and Health Act (WISHA), enacted in 1973, and adopted OSHA's PSM standard when it was promulgated in 1992. In 1998, seven refinery workers were killed by an explosion and fire in an Anacortes refinery, then owned by Equilon Enterprises, now operated by Holly Frontier. On April 2, 2010, an explosion and fire erupted in the Naphtha Hydrotreater Unit at the Tesoro Refinery in Anacortes, killing seven refinery workers. The tragedy is the worst Washington State industrial incident to-date.

In spite of these incidents, L&I's Division of Occupational Safety and Health (DOSH) has continued to receive complaints and referrals alleging unsafe conditions in Washington State refineries. Subsequent inspections have identified the deficient application of the process safety management rule by refinery employers, leading to citations and their affiliated penalties.

[139] RCW 34.05.328(1)(e).
[140] RCW 49.17.010.

Associated violation abatements have not resulted in a meaningful reduction in unsafe practices in these facilities. Based on the foregoing, maintaining the regulatory status quo is insufficient in addressing risks and preventing future incidents.

7.2 Safety Case Regulatory Approach

The second approach considered was the Safety Case Regulatory approach. While not included in the final reports, the CSB January 2014 Tesoro Anacortes Refinery Draft Investigative Report[141], explosion and the CSB April 2013 Chevron Richmond Refinery Interim Investigative Report[142] included recommendations to move to the "safety case regulatory approach". This an alternative regulatory approach, used in other countries, under which there is less prescriptive regulation and more focus on comprehensive safety plans developed by facilities. Neither the final CSB Tesoro Anacortes Refinery Investigation Report nor the final CSB Chevron Richmond Refinery Investigative Report included recommendations to move to the Safety Case approach.

The California's Interagency Refinery Task Force 2014 report[143] states the following regarding the Safety Case model:

Several countries have adopted the safety case model to reduce risks in complex industrial processes such as refineries. Under this model, government agencies evaluate, license and permit the operation of a facility based on the facility's successful development and implementation of a comprehensive safety plan (the employer's "safety case") covering all aspects of the operation. The safety case model relies on industry expertise in self-policing, but it may also allow workers to participate more fully in safety decisions. The experience of the countries where the safety case model has been established indicates several regulatory prerequisites for success, including:

[141] https://www.csb.gov/assets/1/20/tesoro_anacortes_2014-jan-29_draft_for_public_comment.pdf?15119
[142] https://www.csb.gov/assets/1/17/draft_report_for_public_comment.pdf?14934
[143] https://ww2.arb.ca.gov/sites/default/files/classic/isd/fuels/carefinery/crseam/refinerysftyrpt.pdf

- *A designated governmental unit dedicated to enforcement at complex facilities and a large number of inspectors to conduct the initial licensing evaluation and periodic audits;*

- *A specialized skill set and a high competence level among inspectors, including chemical and mechanical engineers, process plant operators and social science experts, who are able to evaluate technical refinery operations as well as human factors, training effectiveness, safety culture, and other factors;*

- *Salaries and benefits that typically are higher than other regulatory compliance officers in order to hire and retain highly qualified inspectors;*

- *A dedicated funding source (general fee, licensing or certification fees, fees for service) paid by the industry; and,*

- *A substantial change in the regulatory framework to allow regulators to require refinery operators to adopt policies and practices beyond those that are required under existing law.*

Given the draft recommendation and the use of the model in other countries, L&I reviewed the Safety Case model and determined it was not the least feasible option. It is a paradigm shift from the current regulatory model under L&I's current PSM rules, OSHA's PSM rules, and California PSM rules and their Refinery PSM rules. Implementing this approach would require significant efforts and resources to change the current statutory and regulatory framework, in addition to significant resources for ongoing implementation and enforcement. For Washington, which has 5 refineries, to make this shift absent other states with more refineries or federal OSHA, it is not the least burdensome option.

The chart below identifies all the provisions required to be analyzed and the rationale for the adopted change.

Process Safety Management Program	**The employer is required to develop and implement an effective written PSM program. The purpose of the PSM program is to oversee and coordinate the refinery's compliance with all elements of the adopted PSM section, in order to ensure compliance and continual improvement in all PSM elements.**
WAC 296-67-311(1) A requirement has been added that designates the refinery plant manager as the person of authority and responsibility for the application of the PSM rule in the facility.	This is necessary because employers have the responsibility, at all levels, to provide a safe workplace that does not have serious hazards. A process safety program specific to the refining industry is a critical component with which to meet that responsibility.
WAC 296-67-311(2) A requirement has been added that directs the refinery employer to develop, implement, and maintain a written PSM program that must be reviewed and updated every three years.	This is necessary since employers need to develop the necessary expertise, experiences, judgment, and proactive initiative within their workforce to properly implement and maintain an effective process safety management program. A written PSM program will facilitate this process.
WAC 296-67-311(3) A requirement has been added that directs the refinery employer to develop, implement, and maintain an organizational chart that identifies management positions responsible for implementing PSM program elements.	This is necessary so that the employer can visually demonstrate a high-level commitment to PSM compliance, and to ensure management accountability.
WAC 296-67-311(4) A requirement has been added that directs the refinery employer to develop, implement, and maintain a tracking program that assesses	This is necessary in order to assure that recommendations, reports of hazards, temporary repairs, and any other notifications

leading, lagging, and process safety performance indicators.	are documented and tracked through resolution.
Employee Collaboration	**These adopted requirements are necessary to ensure that the recommendations of employees and employee representatives are afforded systematic and comprehensive attention by a refinery, and that refineries provide employees and employee representative's access to documents and information necessary for the employees to participate meaningfully in the safe operation of the refinery.**
WAC 296-67-315(1)(a) A requirement has been expanded that directs the refinery employer to develop, implement, and maintain a written plan to effectively provide for employee collaboration and inclusion in the PSM program elements: Process hazard analyses;(PHAs) Damage mechanism reviews (DMRs); Hierarchy of hazard controls analyses (HCAs); Management of change assessments (MOCs); Management of Organizational change assessments (MOOCs); Process safety culture assessments (PSCAs), Incident investigations; Development and maintenance of process safety information; Safeguard protection analyses (SPAs); and Pre-startup safety reviews (PSSRs).	This is necessary to ensure that there is meaningful participation and decision making for affected operating and maintenance employees and employee representatives in all program teams for all analyses required.
WAC 296-67-315(1)(b) A requirement has been clarified that directs the refinery employer to effectively collaborate with affected operating and maintenance employees and employee representatives, throughout all phases, in the development, training, implementation, and maintenance of all PSM elements.	This is necessary to ensure that there is meaningful participation and decision making for affected operating and maintenance employees and employee representatives in all program teams for all analyses required.

WAC 296-67-315(1)(c) A requirement has been clarified that directs the refinery employer to provide access by employees and employee representatives to all documents or information developed or collected by the employer, including information that might be subject to protection as a trade secret.	Process safety elements are linked together with respect to analyses, operating procedures, inspection and testing reports, and the physical properties of the highly hazardous chemicals in the processing environment. Sharing such information with employees is necessary to afford them the knowledge they need in order to protect themselves.
WAC 296-67-315(2) A requirement has been added that gives authorized collective bargaining agents the authority to select their own representatives to participate in PSM program development and implementation planning, including the PSM teams and other activities.	This is necessary to clarify that participation in the overall PSM program development and implementation planning is from onsite employees and not from representatives who may or may not be employees of the refinery.
WAC 296-67-315(3) A requirement has been clarified that directs the refinery employer to establish a process for selecting employee representatives. For employees who are not represented by an authorized collective bargaining agent, the employer is required to establish effective procedures for the selection of employee representatives.	This is necessary to clarify that participation in the overall PSM program development and implementation planning is performed consistently and inclusive of all affected employees.
WAC 296-67-315(5)(a)(ii-iv) A requirement has been added that directs the refinery employer, within 90 days, to develop effective stop work procedures that provide the authority of all employees, including employees of contractors to recommend work stoppage that they believe could cause serious harm or death; the authority of qualified operators to partially or completely shut down an operation or process, and protection for employees from intimidation, retaliation, or discrimination.	Initiating a 'stop work' action allows the employer to correct safety hazards and halt potentially unsafe actions before they happen. This time period provides the employer with a flexible period of time to respond to written reports of hazards. Effective employee collaboration is necessary to ensure process safety in all refinery operations because employees are often the first to become aware of process safety hazards. Employees have direct experience with the routine operation or maintenance of a process.

WAC 296-67-315(5)(b) A requirement has been added that directs the refinery employer to develop, implement, and maintain effective procedures to ensure the right of all employees, including the employees of contractors to anonymously report hazards.	The option of anonymously reporting hazards is necessary in order to uncover and address potential hazards which reduces the risk of workplace accidents, with the attendant costly injuries, lost productivity, and potential legal liabilities. This requirement is necessary to provide procedures for employees and other individuals to take action in response to hazards without fear of retaliation. This also allows employee representatives to raise health and safety concerns with the employer on behalf of an employee if the employee chooses to remain anonymous.
WAC 296-67-315(6)(a)-(c) A requirement has been added requiring the refinery employer to document recommendations and reports associated with the shutdown of an operation or process; partial or complete shutdown of an operation or process; written reports of hazards, and the employer's response.	This is necessary because multichannel communication, documentation, and feedback provides the best opportunity for operators to establish and maintain a mutual understanding of the process unit and its expected future state. During times of non- routine operating conditions such as unit shutdown, the risk of operators having dissimilar or incompatible understanding of the state of the process unit is even greater. Recommendations and other documented, relevant information will help ensure safe work procedures for shutdowns.
Process Safety Information	**Section 67-319 requires the employer to develop and maintain comprehensive Process Safety Information (PSI) pertaining to refinery processes. For each process, the employer is required to compile information on the hazards of highly hazardous materials used in or produced by the process; the technology of the process; process equipment used in the process; and results of previous DMRs. This information is required in advance of conducting a PHA, HCA, Safeguard**

	Protection Analysis (SPA), or DMR for the process.
WAC 296-67-319(1)(b)-(d) A requirement has been expanded that directs the refinery employer to develop and maintain a compilation of written PSI before conducting an HCA, SPA, or DMR.	This is necessary so that complete and accurate written information concerning process chemicals, process technology, and process equipment can contribute to an effective process safety management program. Process safety information is a body of critical information that is relied upon when performing HCAs, SPAs, and DMRs.
WAC 296-67-319(3)(d) A requirement has been expanded that directs the refinery employer to include damage mechanism reviews (DMRs) in their PSI.	This is necessary since processes, technology, maintenance, and equipment changes over time. Any changes to process chemistry or other component of a process may trigger a damage mechanism. Information contained in a DMR can have a direct correlation to equipment inspection and testing schedules.
WAC 296-67-319(4)(d) A requirement has been expanded that replaces the word "corrosivity data" with "damage mechanism data."	This is necessary because there are many types of damage mechanisms in a refinery environment; and corrosion is only one. A comprehensive understanding of all damage mechanisms in a facility has a direct impact on the safety of workers.
WAC 296-67-319(6)(i)-(j) A requirement has been expanded that directs the refinery employer to include electrical supply and distribution systems and the results of damage mechanism reviews (DMRs) to information about the equipment of the process.	Electrical supply and distribution systems and DMR results accompany existing information requirements. This is necessary to ensure the maintenance and safe operation of process equipment that directly affects worker safety.
WAC 296-67-319(7) A requirement has been added that allows the employer to include more protective internal practices than those found in RAGAGEP sources.	This requirement allows employers to form internal practices for inspections, testing, and other activity. An employer's internal standards may be more stringent than other relevant external resources. More-stringent standards may be needed to adequately control hazards due to the unique characteristics of the employer's process. In

	all cases the employer must document that its equipment complies with RAGAGEP. This is necessary for the safe operation of process equipment.
WAC 296-67-319(8) A requirement has been expanded that directs the employer to assure that new process equipment for which no RAGAGEP exists is constructed and installed in a safe manner.	If the employer installs new equipment for which no RAGAGEP exists it must document that the equipment is designed, constructed, installed, maintained, inspected, tested and operated in a safe manner. This documentation is necessary to provide transparency and accountability in the employer's programs to ensure the quality, integrity, and appropriateness of all process equipment and procedures for maintaining, inspecting, and testing the equipment.
WAC 296-67-319(9) A requirement has been expanded that directs the refinery employer to include construction and installation documentation for existing equipment that was designed in accordance with RAGAGEP or other codes, standards, or practices that are no longer in general use.	If the employer has equipment for which codes, standards, or practices no longer in general use, it must document that the equipment is designed, constructed, installed, maintained, inspected, tested and operated in a safe manner This documentation is necessary to provide transparency and accountability in the employer's programs to ensure the quality, integrity, and appropriateness of all process equipment and procedures for maintaining, inspecting, and testing the equipment.
Hazard Analyses	**The PHA team is required to assess scenarios and analyze potential causes and consequences of potential incidents. The team assesses the safeguards that are in place to prevent or mitigate the different accident scenarios to determine if additional safeguards are needed. The PHA team communicates its findings and recommendations to the refinery management, which uses this information to implement corrective actions to ensure the safety and integrity of the process.**

	The purpose of the SPA is to determine the overall and combined effectiveness of the safeguards for each of the failure scenarios that have the potential for a major incident. This is necessary to ensure that the employer applies a quantitative or semi-quantitative safety analysis for process safety hazards identified in a PHA. **The employer is required to ensure the safety and integrity of refinery processes by applying inherent safety measures and safeguards in a specific sequence and priority order through the performance of a hierarchy of hazards control analysis (HCA). Prioritizing control methods makes the workplace safer, reduces costs, and eliminates waste.**
WAC 296-67-323(1)(a) A requirement has been expanded that directs the refinery employer to perform PHAs for processes not previously covered by WAC 296-67 Part A within three years of the effective date of Part B.	This is necessary because a PHA provides information which will assist employers and employees in making decisions for improving safety and reducing the consequences of unwanted or unplanned releases of hazardous chemicals.
WAC 296-67-323(1)(b)(vii) A requirement has been expanded to include PHA methods recognized by engineering organizations or governmental agencies.	Providing the employer with latitude when deciding which PHA methodology to use ensures the quality and appropriateness of the methodology selected for the hazards in the process.

WAC 296-67-323(1)(c)(ii),(iii), (iv), (ix) A requirement has been expanded that directs the refinery employer to address additional factors in the PHA. These include: Previous publicly documented process safety incidents in the petroleum refinery and petrochemical industry sectors that are relevant to the process; DMR reports that are applicable to the process; HCA reports that are applicable to the process; and the potential effects of external events, including seismic events, if applicable.	This ensures the accuracy and integrity of the information used in the PHA. Access to this information is necessary to address the hazards and potential consequences using the best information available. This promotes safe operation and minimizes or eliminates process safety hazards. Outcomes of previous incidents and external events provide a historical record to inform current and future safety practices.
WAC 296-67-323(1)(d) A requirement has been expanded that directs the refinery employer to assemble a team qualified to perform the PHA that includes individuals with expertise in damage mechanisms, process chemistry, safeguard protection analysis, and control systems.	This is necessary to ensure the PHA is performed by individuals with the required expertise, including at least one member who routinely works on the process and who understands the current operating conditions. This is also necessary to promote employee collaboration and transparency.
WAC 296-67-323(1)(f)(i)-(iii) A requirement has been added that directs the refinery employer to document recommendations arising from the safeguard protection analysis in the PHA report.	Identifying safeguard deficiencies during the course of performing a PHA ensures the integrity of the process and provides an additional layer of protection against a catastrophic release.
WAC 296-67-323(2)(a)(i)-(iv) A requirement has been added that directs the refinery employer to perform a safeguard protection analysis (SPA) for each scenario in the PHA that identifies the potential for a process safety incident. The SPA must include an effective written safeguard protection analysis to determine the effectiveness of existing individual safeguards; evaluate the combined effectiveness of all existing safeguards for each failure scenario in the PHA; the individual and combined effectiveness of safeguards recommended in the PHA; and the	This is necessary in order to evaluate high-consequence scenarios by determining the combination of the probability of an occurrence and severity of consequences.

individual and combined effectiveness of additional or alternative safeguards that may be needed.	
WAC 296-67-323(2)(b) A requirement has been added that directs the refinery employer to ensure that all independent protection layers for each failure scenario must be independent of each other and independent of initiating causes.	This is necessary to isolate safeguards and prevent sequential failure. The employer is required to use a quantitative or semi-quantitative SPA method to identify the most protective safeguards. An independent layer of protection is a system, action, or an item that mitigates the risk associated with a hazardous scenario.
WAC 296-67-323(2)(c) A requirement has been added that directs the refinery employer to utilize a quantitative or semi-quantitative method to identify the most protective safeguards. The employer must evaluate site-specific failure rate data, or in the absence of such data, industry failure rate data for each device, system, or human factor.	This is necessary because quantitative and semi-quantitative risk analysis categorize risks by comparative scores rather than by specific probability and financial or other measures. It is in this way that the most protective safeguards can be identified.
WAC 296-67-323(2)(d) A requirement has been added that directs the refinery employer to ensure that the SPA is performed by qualified individuals with expertise in the safeguards within the process, as well as employee representatives. The SPA may be performed as part of the PHA or as a stand-alone analysis.	This is necessary for transparency and accountability and to ensure that SPAs are performed by individuals with the required expertise.
WAC 296-67-323(2)(e) A requirement has been added that directs the employer to document the likelihood of all potential initiating events, including equipment failures, human factors, loss of flow control, loss of pressure control, loss of temperature control, loss of level control, excess reaction, and other conditions that may lead to a loss of containment. The SPA must	The employer is required to document the likelihood and severity of all potential initiating events as well as the risk reduction achieved by each safeguard in the SPA. This is necessary to ensure accountability and transparency of the analysis and selection of effective safeguards.

document the risk reduction achieved by each safeguard for all potential initiating events.	
WAC 296-67-323(2)(f) A requirement has been added that directs the refinery employer to complete all SPAs within six months of the completion or revalidation of the PHA.	This is necessary to ensure appropriate safeguards are installed in a timely manner.
WAC 296-67-323(3)(a)(i-iv) A requirement has been added that directs the employer to perform an HCA in a timely manner for all recommendations made by a PHA team for each scenario that identifies the potential for a process safety incident; for all recommendations that result from the investigation of a process safety incident; as part of managing changes, whenever a major change is proposed; and during the design and review of new processes and new facilities, and their related process equipment.	This is necessary to ensure that, when a PHA team identifies the potential for a major incident, the employer implements protections prioritized by the highest order of inherent safety.
WAC 296-67-323(3)(b) A requirement has been added that directs the refinery employer to update and revalidate the HCA as a standalone analysis at least once every five years.	This is required in order to ensure that HCAs are conducted in a timely manner.
WAC 296-67-323(3)(c) A requirement has been added that directs the refinery employer to document and perform the HCA by a team with expertise in engineering and process operations. The team must include one member knowledgeable in the HCA methodology being used, and at least one operating employee who currently operates the process and has expertise and experience in the process being evaluated. As necessary, the team must consult with individuals with expertise in damage	Employers are required to consult individuals with expertise in damage mechanisms, process chemistry, and control systems as needed. This is necessary to ensure adequate expertise and employee collaboration when performing the HCA.

mechanisms, process chemistry, and control systems.	
WAC 296-67-323(3)(d) A new requirement has been added that directs the employer to assure that the HCA team must compile or develop all risk relevant data for each process; Identify, characterize, and prioritize risks posed by each process safety hazard; Identify, analyze and document all inherent safety measures and safeguards for each process safety hazard in the following sequence and priority order, from most preferred to least preferred: First order inherent safety measures, second order inherent safety measures; passive safeguards, active safeguards, and procedural safeguards. The employer must document relevant publicly available information inherent safety measures and safeguards. The inherent safety measures and safeguards that have been achieved in practice by the petroleum refining industry and related industrial sectors; and required or recommended for the petroleum refining industry by a federal or state agency or in a regulation or report. For each process safety hazard identified, develop written recommendations in the following sequence and priority order: Eliminate hazards to the greatest extent feasible using first order inherent safety measures, reduce any remaining hazards to the greatest extent feasible using second order inherent safety measures; effectively reduce remaining risks using passive safeguards; effectively reduce remaining risks using active safeguards; and	This is necessary to ensure inherently safer strategies are prioritized and identified to eliminate and reduce risk.

effectively reduce remaining risks using procedural.	
WAC 296-67-323(3)(e)(i)-(v) A requirement has been added that directs the refinery employer to complete the HCA report within ninety calendar days of developing recommendations. The employer must append the HCA report to the PHA report. The report must include specific descriptions of the composition and qualification of the team; the HCA methodology used by the team; each process safety hazard analyzed by the team; the inherent safety measures and safeguards analyzed by the team; and the rationale for the inherent safety measures and safeguards recommended by the team for each process safety hazard.	These requirements are necessary to ensure transparency and accountability in the HCA process and to assess the extent to which refinery employers accept, alter, or reject recommendations made by HCA teams.
WAC 296-67-323(4) A requirement has been added that directs the employer to implement all recommendations pursuant to WAC 296-67-383, Corrective action program.	This requirement is necessary to ensure that the employer takes corrective action to implement HCA team recommendations in a timely manner.
WAC 296-67-323(5) A requirement has been added that directs the refinery employer to retain SPAs, and HCAs; and documented resolution of recommendations for the life of the process.	This is requirement is needed because report retention is necessary to enable monitoring and evaluation over time.
Operating Procedures	**The employer is required to develop operating procedures for the purpose of ensuring safety during all operating phases and modes of operation for each process, managing deviations in process operating limits, protecting employees from process safety hazards, ensuring the proper function of safety systems, and safely responding to upset or emergency conditions on a process. The employer is**

	required to ensure that information in the Operating Procedures is accurate and consistent with the PSI. The employer is required to review and update the Operating Procedures as often as necessary to ensure that they reflect current, safe operating practices, as well as annually certify that they are accurate. Operating Procedures include any changes that result from alterations in process chemicals, technology, personnel, process equipment, or other changes to the facility. Changes to Operating Procedures must be managed under the MOC requirements.
WAC 296-67-327(1)(a)(viii) A requirement has been added that directs the employer to consider any other operating conditions when writing operating procedures.	Comprehensive operating procedures are necessary to ensure the safe operation and maintenance of refinery processes and equipment under all operating conditions.
WAC 296-67-327(3) A requirement has been expanded that directs the refinery employer to include the alteration of personnel as part of the operating procedure review process.	Accurate and current operating procedures are necessary to ensure safe operation of the refinery.
WAC 296-67-327(5)(a)-(c) A requirement has been added that directs the refinery employer to include emergency procedures for each process that gives authority to qualified operators to initiate emergency procedures. Before allowing any employee in the vicinity of a leak, release, or discharge, the subsection requires the employer, at a minimum, define the conditions for handling leaks, spills or discharges of highly hazardous chemicals or materials that provide a level of protection that is functionally equivalent to, or safer than shutting down or isolating the process; isolate any vessel piping and equipment	This is necessary to protect employee safety during a leak, release, or discharge of the highly hazardous material.

where a leak, spill, or discharge is occurring; or shut down and depressurize all process operations where a leak, release, or discharge is occurring.	
WAC 296-67-327(6)(d) A requirement has been expanded that directs the employer to include the handling, controlling, and stopping leaks, spills, releases and discharges of highly hazardous chemicals or materials as part of the facility written safe work practices.	Requiring the employer to develop safe work practices for these activities is necessary to protect the safety of employees and contractor employees and contractor employees who perform these tasks.
Training	**The purpose of this adopted subsection is to set forth requirements to ensure that refinery operating and maintenance employees are effectively trained to perform their jobs safely. Effective training requires a comprehensive approach to identifying hazardous conditions and training employees to take actions to mitigate those conditions in ways that protect employee safety and the integrity of the process. The adopted subsection requirements are necessary to (1) ensure that refinery employers develop and implement effective training programs; (2) involve employees in developing and implementing these programs; and (3) ensure the competency and qualifications of refinery employees.**
WAC 296-67-331(1)(a) A requirement has been clarified that directs the employer to train each affected employee involved in operating a process in an overview of the process and in the applicable operating procedures.	This provision is necessary to ensure that each operating and maintenance employee receives a baseline level of training before being assigned to a process and that the training emphasizes process hazards that could affect the safety or health of the employee. By requiring specific training in emergency operations and shutdown, the proposal ensures that emergency operations are carried out by employees who are properly trained.

WAC 296-67-331(1)(b) A requirement has been clarified that directs the refinery employer to train affected maintenance employees, including the affected employees of contractors, about the process and in the hazards and safe work practices related to the process.	This provision is necessary to ensure that each operating and maintenance employee receives a baseline level of training before being assigned to a process and that the training emphasizes process hazards that could affect the safety or health of the employee. By requiring specific training in emergency operations and shutdown, the proposal ensures that emergency operations are carried out by employees who are properly trained.
WAC 296-67-331(2)(b) A requirement has been clarified that directs the refinery employer to provide effective refresher and supplemental training to maintenance employees every three years, or more often if necessary.	Refresher and supplemental training ensures that all employees are working with the same understanding of the process conditions and procedures. The proposal requires the employer to consult with employees in determining the frequency and content of refresher training.
WAC 296-67-331(3)(b) A requirement has been added that directs the employer to include the signature of the persons who administer training as part of the training certification record.	This provision is necessary to ensure the effectiveness of the initial, refresher, and supplemental training programs required for refinery employees.
WAC 296-67-331(4)(a)-(b) A requirement has been added that directs the refinery employer to develop, implement, and maintain an effective written program describing the requirements that an employee must meet in order to be designated as qualified; and employee testing procedures for subject matter verification.	This provision is necessary to ensure that employees are qualified to perform the tasks specific to the position(s) they are assigned, including the health and safety aspects of the position. This provision helps prevent employees from being assigned to positions for which they are not qualified. A written qualification process ensures standardized testing procedures for verifying understanding and competency in job skill levels and work practices.
WAC 296-67-331(5) A requirement has been added that directs the refinery employer to develop and implement a training program within 24 months of the effective date of Part B of this chapter.	This provision is necessary because the adopted regulations contain seven new PSM elements that have a direct impact on employee safety and health and require the employer to effectively involve employees.

Employees and their representatives must be trained to understand all PSM elements; and employees and employee representatives collaborating as part of a team must be trained in the PSM elements relevant to that team.	
Contractors	**The purpose of this adopted subsection is to set forth requirements that ensure the competency of contractors who perform work in a refinery, particularly regarding their understanding of process safety hazards, their adherence to refinery safety procedures, and the effectiveness of their employee safety training programs.**
WAC 296-67-335(2)(b) A requirement has been added that requires the refinery employer to inform the contractor and must ensure that the contractor has informed each of its employees of the following: Potential process safety hazards associated with the contractor's work; applicable refinery safety rules; and applicable provisions for emergency planning and response; and employee emergency plans and fire prevention plans.	This requirement is necessary to ensure that the refinery employer is accountable for the safety of contractors and contractor employees. The provision ensures that contractors and contractor employees are informed of the process safety hazards in the refinery and applicable safety procedures, including what actions to take in the event of an emergency.
WAC 296-67-335(2)(c) A requirement has been added that directs the refinery employer to develop, implement, and maintain effective written procedures in addition to safe work practices with respect to the safe entry, presence and exit of contractor employees pursuant to WAC 296-67-327.	This requirement is necessary to ensure the security of the facility, including control of access and work in the process area. This is necessary to protect the health and safety of workers who enter and exit the process area.
WAC 296-67-335(3)(a)(i)-(iv) A requirement has been clarified that directs the contract employer to effectively train their employees in the work practices they need to safely perform their jobs, Potential process safety hazards related to their jobs; Applicable refinery safety and health rules;	This requirement is necessary because work in a refinery is inherently hazardous. For example, because of the potential presence of flammable vapors, welding near a refinery process is inherently more hazardous than welding at a commercial construction site. Likewise, performing welding at one refinery

The specific actions to take in an emergency; and Applicable provisions of this chapter, including the provisions of the WAC 296-67-367 Emergency planning and response, and WAC 296-24-567 Employee emergency plans and fire prevention plans.	is likely to be different from performing the same job at another refinery, where process conditions can vary. To perform work safely, and to protect the integrity of the process, contractor employees must receive training specific to the hazards of the refinery job site and specific petroleum process unit.
WAC 296-67-335(4) A requirement has been clarified that provides for the sharing of trade secret information between the refinery employer and the contractor employer through entering into a confidentiality agreement.	This is necessary for the proper communication of hazards to workers regardless of its proprietary status, which affords workers the ability to perform their work safely.
Pre-start up safety review	**The employer is required to conduct a PSSR prior to the start-up of a process and for modified processes. This is necessary to provide relevant information to operators and to ensure the operators are trained on the changes prior to start-up, which ensures safe start-up of the unit.**
WAC 296-67-339(1) A requirement has been expanded that directs the refinery employer to perform a PSSR for partial, planned, or unplanned shutdowns/outages, where activities exceed those covered under an existing procedure; and for turnaround work done on a process.	This is necessary to ensure that the employer carefully assesses the function, performance, and integrity of new or modified processes before starting them. Failure of a single piece of equipment can cause or contribute to a major incident. Requiring a comprehensive PSSR is necessary to ensure safety during the start-up process.
WAC 296-67-339(2)(d) A requirement has been expanded that directs the employer to perform HCAs, DMRs, and SPAs for new processes; and that recommendations have been implemented or resolved before startup. Modified processes and new processes must go through the MOC process.	This requirement is necessary to ensure all damage mechanisms that could affect the integrity of a process are considered; all potential process safety hazards are identified, prioritized, and mitigated; and inherent safety measure and safeguards are effectively applied. For new or modified processes, the employer is required to implement all changes in accordance with the requirements of the MOC procedures. This is necessary to ensure

	proper oversight of process safety before, during, and after implementation of a change.
WAC 296-67-339(3) A requirement has been added that directs the refinery employer to involve affected operating and maintenance employees who have expertise and experience in the PSSR and who have expertise and experience in the operations and engineering of the process being started. An operating employee who currently works in the process, and who has expertise and experience in the process being started must be designated as the employee representative.	The information and experience provided by employees contributes to the safe start-up of a new or modified process and promotes safe operations in the refinery.
Mechanical Integrity	**The adopted requirements are necessary to ensure the mechanical integrity and safety of process equipment. The failure of a single piece of equipment can cause or contribute to a major incident. For example, a pressure relief valve that fails to open due to poor inspection and maintenance can result in dangerous over pressuring in a process.**
WAC 296-67-343(1)(c) A requirement has been added that directs the employer to make procedures and inspection documents accessible to employees, employee representatives, and affected employees of contractors who are performing work on process equipment and whose job tasks expose them to process safety hazards.	This is necessary to ensure the accountability and transparency of information, which promote employee safety. Providing information to employees and representatives helps ensure the effectiveness of the program.
WAC 296-67-343(2)(b)(iii) A requirement has been added that allows the refinery employer to use internal practices	The requirements are necessary to ensure that issues related to the performance of process equipment are identified through testing and inspections to prevent malfunction. The

with respect to inspections and testing, as long as they are more protective than (2)(b)(i) or (2)(b)(ii).	requirements are also necessary to ensure that the employer's internal standards are equally or more protective compared to RAGAGEP.
WAC 296-67-343(3) A requirement has been expanded that directs the employer to use repair methodologies and preventative maintenance consistent with RAGAGEP or more protective internal practices.	This is necessary to ensure that equipment deficiencies are corrected properly, using standards that are equally or more protective compared to RAGAGEP.
WAC 296-67-343(4)(a) A requirement has been expanded that directs the refinery employer to ensure that all process equipment, at a minimum, complies with the criteria established by the process safety information, (PSI); and designed, constructed, installed, maintained, inspected, tested, operated and replaced in compliance with manufacturer's and other design specifications and all applicable codes and standards.	This is necessary to ensure that employers meet or exceed recognized standards and implement changes in response to new or updated codes and standards that may be amended in response to process incidents in the industry. This is necessary to promote safe operation and ensure that process equipment complies with current standards. This protects the safety of employees and the integrity of refinery processes.
WAC 296-67-343(4)(b) A requirement is being expanded that directs the refinery employer to document that new process equipment or existing process equipment for which no RAGAGEP exists is designed, constructed, installed, maintained, inspected, tested and operated in a safe manner.	This is necessary to ensure that employers meet or exceed recognized standards and implement changes in response to new or updated codes and standards that may be amended in response to process incidents in the industry. This is necessary to promote safe operation and ensure that process equipment complies with current standards. This protects the safety of employees and the integrity of refinery processes.
WAC 296-67-343(4)(e) A requirement is being added that directs the refinery employer to establish a process for evaluating new or updated codes and standards and implementing changes as appropriate to ensure safe operation.	This is necessary to promote safe operation and ensure that process equipment complies with current standards. This protects the safety of employees and the integrity of refinery processes.

WAC 296-67-343(5)(f) A requirement is being added that directs the refinery employer to evaluate substantially similar equipment across the facility once a failure mechanism is found in process equipment in a single location.	This is necessary since all processes are interconnected; and process conditions in one process can have an impact in others. Once an equipment failure is identified, the employer must assume that a failure could occur in substantially similar equipment.
Damage Mechanism Review	**A DMR is necessary to identify deficiencies in and degradation of the mechanical and structural integrity of processes. A DMR assists in determining the appropriate selection of construction materials and inspection frequency. This is necessary to help prevent process failures that could cause employee injuries or incidents.**
WAC 296-67-347(2) A requirement is being added that directs the refinery employer to complete no less than fifty percent of initial DMRs within three years and all remaining DMRs within five years of the effective date of the rule.	The imposed time limits are necessary to ensure that damage mechanisms are identified and prioritized in a timely manner.
WAC 296-67-347(3) A requirement is being added that directs the refinery employer to revalidate the DMR at least once every five years.	The proposal integrates the DMR schedule with the PHA schedule, which gives the employer flexibility in aligning priorities for implementation. By aligning with the PHA schedule, the adopted DMR schedule improves the integration of DMR findings into PHAs for each process.
WAC 296-67-347(4) A requirement is being added that directs the refinery employer to review the DMR as part of a major change on a process for which a damage mechanism already exists, prior to approval of the change. If a major change may introduce a damage mechanism, a DMR must be performed prior to approval of the change.	This is necessary to ensure damage mechanisms are evaluated for all processes. This ensures the integrity of the process and prevents newly introduced or unknown hazards from causing unintended safety consequences.

WAC 296-67-347(6) A requirement is being added that directs the refinery employer to make the DMR for a process available to the team performing a PHA for that process.	By aligning with the PHA schedule, the adopted DMR schedule improves the integration of DMR findings into PHAs for each process.
WAC 296-67-347(7) A requirement is being added that directs the refinery employer to assemble a DMR team with expertise in engineering, equipment and pipe inspection, damage and failure mechanisms, and the operation of the process or processes under review. The team must include one member knowledgeable in the specific DMR methodology being used.	This is necessary because damage mechanisms are complex and require specialized knowledge, including DMR methodology.
WAC 296-67-347(8)(a)-(e) A requirement is being added that directs the refinery employer to include the assessment of process flow diagrams, identification of all potential damage mechanisms, determination that the materials of construction are appropriate for their application and are resistant to potential damage mechanisms, methods to prevent or mitigate damage, and review of operating parameters to identify operating conditions that could accelerate or otherwise worsen damage, or that could minimize or eliminate damage in the DMR.	This is necessary to ensure the comprehensiveness of the DMRs performed and establish a consistent performance standard.
WAC 296-67-347(9) An expanded description has been added that includes damage mechanisms as mechanical loading failures such as ductile fracture, brittle fracture, mechanical fatigue, and buckling; erosion, such as abrasive wear, adhesive wear, and fretting; corrosion, such as uniform corrosion, microbiologically induced corrosion, localized corrosion, and pitting; thermal-related failures such as creep, metallurgical transformation, and thermal	The physical damage to pipes, valves, and other process equipment caused by these damage mechanisms has been identified as a cause of serious process failures in refineries. This subsection is intended to provide examples of damage mechanisms found in refineries.

fatigue; cracking, such as stress corrosion cracking; and embrittlement, such as high temperature hydrogen attack.	
WAC 296-67-347(10) A requirement is being added that directs the refinery employer to include an assessment of previous experience with the process, including the inspection history and all damage mechanism data; a review of industry-wide experience with the process; and all applicable standards, codes and practices in the DMR.	This is necessary to ensure that the DMRs performed by the employer are complete and that refineries learn from their own experience with the process. Requiring a review of the industry-wide experience with damage mechanisms for a specific process is necessary to ensure that all refineries benefit from the experience of others.
WAC 296-67-347(11)(a)-(d) A requirement has been added that directs the refinery employer to prepare a written DMR report that must include the process and damage mechanisms analyzed, results of all analyses performed, recommendations for temporarily mitigating damage, and recommendations for preventing damage.	Documentation is necessary to ensure that the required DMR information is recorded by each refinery and retained over time, ensuring transparency and accountability of damage mechanism identification, control, and mitigation. This risk-based assessment enables the employer to anticipate problems and budget time and materials necessary to proactively mitigate potential problems and ensure the integrity of the process. Standardized DMR reporting requirements are necessary for monitoring and evaluation over time and across the industry.
WAC 296-67-347(12) A requirement has been added that directs the employer to provide and review the DMR report with affected employees, including affected employees of a contractor, whose work assignments are within the scope of the process evaluated in the DMR.	Documentation is necessary to ensure that the required DMR information is recorded by each refinery and retained over time, ensuring transparency and accountability of damage mechanism identification, control, and mitigation. This risk-based assessment enables the employer to anticipate problems and budget time and materials necessary to proactively mitigate potential problems and ensure the integrity of the process. Standardized DMR reporting requirements are necessary for monitoring and evaluation over time and across the industry.

WAC 296-67-347(13) A requirement has been added that directs the employer to implement all recommendations pursuant to WAC 296-67-383, Corrective action program.	This requirement is necessary to ensure accountability and transparency and ensure that the employer takes appropriate and timely corrective actions to implement DMR recommendations.
WAC 296-67-347(14) A requirement has been added that directs the employer to retain DMR reports for the life of the process.	Documentation is necessary to ensure that the required DMR information is recorded by each refinery and retained over time, ensuring transparency and accountability of damage mechanism identification, control, and mitigation. This risk-based assessment enables the employer to anticipate problems and budget time and materials necessary to proactively mitigate potential problems and ensure the integrity of the process. Standardized DMR reporting requirements are necessary for monitoring and evaluation over time and across the industry.
Hot Work	**The employer is required to develop, implement, and maintain written procedures for the issuance of permits to contractors and others who perform hot work on the refinery property. Hot work refers to electric or gas welding, cutting, brazing, or any similar heat-, flame-, or spark-producing procedure or operation**
WAC 296-67-351(1) A requirement has been added that directs the refinery employer to develop, implement, and maintain written procedures for the issuance of permits.	This is necessary to ensure that the employer controls hot work operations in a consistent manner, using standard procedures to ensure that all potential hazards have been identified and mitigated prior to starting hot work, during the work process, and at the conclusion of the work.
WAC 296-67-351(3)(c) A requirement has been expanded that directs the refinery employer to document the name and employer of the person performing the hot work.	Adding the name of the worker onto the permit for that work allows the refinery employer to verify that the contractor worker has been properly trained to do that work, and

	they understand the process hazards that exist in the process.
WAC 296-67-351(4) A requirement has been expanded that directs the refinery employer to retain hot work permits for the duration of one year.	Hot work permits are a type of record. They can be evaluated after an incident and may be valuable to a team investigating the incident. They can also be reviewed by teams performing analyses and can contribute to predictive maintenance.
Management of Change	**The purpose of this section is to require refinery employers to develop, implement, and maintain effective written MOC procedures in order to manage changes in process chemicals, technology, procedures, process equipment, or facilities. MOC procedures provide a rigorous review process to ensure that a proposed change—including a temporary change—does not introduce a new hazard or increase the risk of an existing hazard**
WAC 296-67-355(2)(b) A requirement has been expanded that directs the refinery employer to evaluate the potential process safety impacts of the change including, but not limited to, new process safety hazards or worsening an existing process safety hazard.	This is necessary because refinery processes are highly complex and interconnected. A change made in one location could create a hazard in another. Making changes through a structured program allows for consistency and safety.
WAC 296-67-355(3) A requirement has been added that directs the refinery employer to review or perform a damage mechanism review (DMR) and perform a hierarchy of hazard controls analysis (HCA) prior to making the change. The findings of the DMR and recommendations of the HCA must be included in the MOC documentation.	This is necessary because a major change can introduce new or worsen existing process safety hazards. In some cases, major changes also provide the employer with an opportunity to make improvements in process safety sooner than during a turnaround.
WAC 296-67-355(4)	This requires that individuals with the appropriate level of expertise are used to review a change and that the assessment

A requirement has been added that directs the refinery employer to use qualified personnel and appropriate methods for all MOCs, based upon hazard, complexity and type of change.	method is appropriate for the scale and nature of the adopted change. In addition, the MOC procedures must be performed by qualified individuals in a meaningful, effective manner.
Management of Organizational Change	**The employer is required to effectively manage organizational changes in the refinery. The employer is required to develop, implement, and maintain effective written procedures for changes that could affect operations, engineering, maintenance, health and safety, or emergency response, and are anticipated to exceed 90 days in duration.**
WAC 296-67-359(1) A requirement has been added that directs the refinery employer to develop, implement, and maintain effective written procedures to manage organizational changes.	This is necessary to ensure that the employer's MOOC procedures are current and comprehensive.
WAC 296-67-359(2) A requirement has been added that directs the refinery employer to designate a team to perform a management of organizational change (MOOC) assessment prior to reducing staffing levels, reducing classification levels of employees, changing shift duration, or increasing employee responsibilities at or above 15 percent. The MOOC assessment is required for changes with a duration exceeding ninety calendar days affecting operations, engineering, maintenance, health and safety, or emergency response. This requirement must also apply to employers using employees of contractors in permanent positions.	This requirement is necessary to ensure that organizational changes are reviewed by those with direct experience in process operations or maintenance. In many cases, operators may be the sole source of unique knowledge that they have gained through their experiences. This information can complement the other factors the employer must take into account when considering making organizational changes.
WAC 296-67-359(3) A requirement has been added that directs the refinery employer to document in writing a description of the change being adopted, the	This requirement is necessary to ensure transparency and accountability in the MOOC assessment. A written document is necessary

composition of the team responsible for assessing the adopted change, the factors evaluated by the team, and the team's findings and recommendations.	for appropriate certification by the refinery manager or designee.
WAC 296-67-359(4) A requirement has been added that directs the refinery employer to ensure that the job function descriptions are current and accurate for all positions potentially affected by the change.	A change in employee responsibilities for a particular job, for example, can be assessed only if the job description for that position is current and accurate.
WAC 296-67-359(5) A requirement has been added that directs the refinery employer to designate the refinery manager or designee must certify, based on information and belief formed after reasonable inquiry, that the MOOC assessment is accurate and that the adopted organizational change meets the requirements of this section.	This requirement is necessary to ensure accountability and transparency.
WAC 296-67-359(6) A requirement has been added that directs the refinery employer to include an analysis of human factors in the MOOC assessment.	This requirement is necessary to promote better understanding of behaviors and other human elements in refinery operations and incident prevention, which promotes safe operations.
WAC 296-67-359(7) A requirement has been added that directs the refinery employer inform all employees potentially affected by the change.	This requirement is necessary to ensure accountability and provide transparency of information to affected employees prior to implementation of the change.
Incident Investigation – Root Cause Analysis	**Refinery employers are required to perform effective investigations of incidents that result in, or could reasonably have resulted in, a major incident. The requirements of this subsection would therefore be triggered for any event within or affecting a process that causes—or could reasonably have caused—a fire, explosion, or release of a highly hazardous material,**

	which has the potential to result in death or serious physical harm.
WAC 296-67-363(1) A requirement has been expanded that directs the refinery employer to develop, implement and maintain effective written procedures for promptly investigating and reporting any incident that results in, or could reasonably have resulted in, a process safety incident.	This approach is necessary to ensure that the employer conducts effective investigations for a broad range of incidents to address underlying causes of process failures.
WAC 296-67-363(2) A requirement has been added that directs the refinery employer to include an effective method for performing a root cause analysis within the written procedures.	RCA is a well-established investigation technique used in many industries, including petroleum refining, which improves the quality of an incident investigation. There are different methodologies for conducting RCAs. The proposal does not specify a particular method, which allows flexibility in applying the method that is most effective for the employer's operation.
WAC 296-67-363(3) A requirement has been expanded that directs the refinery employer to perform a Root Cause Analysis.	This is necessary to ensure that the details of the incident are accurately recorded and to identify the root causes. Prompt investigation provides the employer with timely information for taking immediate corrective actions.
WAC 296-67-363(4) A requirement has been clarified that directs the employer to assemble an investigation team that includes a person with expertise in the employer's root cause analysis method, and a person with expertise in overseeing the investigation and analysis. If the incident	The requirements ensure that the team consists of individuals with the expertise necessary to perform an effective investigation, including an RCA. This also ensures that the experience and expertise of employees and contractor employees are

involved the work of a contractor, a representative of the contractor's employees must be included on the investigation team.	effectively represented and integrated into the investigation.
WAC 296-67-363(5) A requirement has been added that directs the refinery employer to use the root cause analysis method to determine the initiating and underlying causes of the incident. The analysis must include the identification of management system failures, including organizational and safety culture deficiencies.	This requirement is necessary to clarify that the RCA is intended to identify any management system failures that may have contributed to the incident. In most cases, these kinds of failures require a thorough and systematic analysis of the events and conditions that cause an incident.
WAC 296-67-363(6) A requirement has been added that directs the refinery employer to determine interim measures that prevent a recurrence or similar incident until final corrective actions can be implemented.	This requirement is necessary because effectively reducing the risk of a similar incident may require the employer to take short-term, interim actions, such as providing additional safeguards, specialized training, revisions to operating procedures, changes to inspection procedures, revalidation of DMR, or other actions that could be implemented in the near term. This requires the employer to mitigate process safety hazards while simultaneously developing a longer-term prevention plan.
WAC 296-67-363(7) A requirement has been added that directs the refinery employer to prepare a written investigation report within ninety calendar days of the incident. If the team demonstrates in writing that additional time is needed due to the complexity of the investigation, the team must prepare a status report within ninety calendar and every thirty calendar day thereafter until the investigation is complete. The team must prepare a final investigation report within five months of the incident.	This is necessary to allow DOSH time to review the report in advance of the six-month statute of limitations. The following eight elements are required in the report.

WAC 296-67-363(8)(d)-(f), (h) A requirement has been expanded that directs the refinery employer to include the following information within the report: identifying direct and indirect causes determined through the root cause analysis; a list of any DMR(s), PHA(s), SPA(s), and HCA(s) that were reviewed as part of the investigation; documentation of relevant findings from the review of DMR(s), PHA(s), SPA(s), and HCA(s); and interim measures implemented by the employer.	This is necessary to ensure that the team evaluates these three types of causes and includes them in the report. Each type of cause is important in the investigation and ensures an accurate and complete analysis. The team reviews the information from each of these analyses, each of which could provide important information relevant to the incident. The team identifies and documents information from any of these analyses that are relevant to the incident. For example, if pipe corrosion was a potential factor in an incident, the investigation team would be required to review the DMR analysis and document whether the DMR findings showed that the pipe was subject to corrosion and whether the employer properly implemented the DMR report's recommendations.
WAC 296-67-363(9) A requirement has been added that directs the employer to implement recommendations pursuant to WAC 296-67-383 Corrective action program.	This is necessary to ensure that the causes of the incident, as identified in the report, are corrected in a timely manner.
WAC 296-67-363(10) A requirement has been added that directs the refinery employer to perform an HCA in a timely manner for all recommendations that result from the investigation of a process safety incident. The employer must append the HCA report to the investigation report.	It is necessary to ensure that the employer identifies, evaluates, and implements the most effective strategies to address the causes of the incident, prioritized by order of inherent safety.
WAC 296-67-363(11) A requirement has been expanded that directs the refinery employer to provide to and upon request, reviewed with employees whose job tasks are affected by the incident. Investigation reports must also be made available to all operating, maintenance and other personnel, including employees of	These requirements are necessary to ensure that all affected employees and their representatives are afforded complete access to the information contained in the report. Requiring the employer to review the report findings and recommendations with employees whose job tasks are affected by the incident is necessary to provide these employees with an opportunity to discuss the

contractors where applicable, whose work assignments are within the facility where the incident occurred or whose job tasks are relevant to the incident findings. Investigation reports must be provided on request to employee representatives and, where applicable, contractor employee representatives.	incident and the report with the employer. These requirements provide transparency of important safety information contained in the incident report.
WAC 296-67-363(12) A requirement has been added that directs the refinery employer to supply any draft or finalized investigation reports to labor and industries' division of occupational safety and health upon written request.	This requirement is necessary in order to inform future recommendations and corrective actions.
WAC 296-67-363(13) A requirement has been expanded that directs the refinery employer to retain incident investigation reports for the life of the process.	This requirement contributes to continual improvement in process safety and helps identify patterns that may be repeated over long periods. This requirement is also necessary to preserve institutional knowledge of process units in refineries in order to inform future recommendations and corrective actions.
Emergency Planning and Response	**This subsection is necessary to ensure that the employer plans effectively for a range of possible emergency conditions. Failing to plan for emergencies endangers employee safety and health and can jeopardize the safety of the process itself**
WAC 296-67-367(1)(a)-(d) A requirement has been clarified that directs the refinery employer to develop an emergency response plan that defines and includes procedures for handling large and small spills or releases; fires; explosions; and any other emergency with a direct bearing on employee safety and health.	This is necessary to ensure that the employer plans effectively for a range of possible emergency conditions. Failing to plan for emergencies endangers employee safety and health, and can jeopardize the safety of the process itself.
WAC 296-67-367(2)	Most Washington State refineries reside outside of municipalities and infrastructure

A requirement has been added that directs the refinery employer to specify how an emergency response will be executed if it exceeds the capability of the employer's internal emergency response team.	such as emergency services. This is necessary because a large incident that exceeds the facility's response capability could become much larger if the facility doesn't have a plan for assistance.
WAC 296-67-367(3) A requirement has been added that directs the refinery employer to document any agreement with external emergency response organizations expected to assist in an emergency. The documentation must include schedules for planned drills.	It is necessary to document such an agreement, so that both parties understand the ability—and limitations—of mutual aid. Performing drills can bring to light any problems that may occur in an actual incident.
Compliance Audits	**An effective compliance audit is a comprehensive evaluation of the past and present conditions of the PSM program at the employers' facilities, in order to develop recommendations for improvement. Internal audits conducted by employers can be very effective at identifying safety issues that might not otherwise be apparent to them.**
WAC 296-67-371(2) A requirement has been expanded that directs the refinery employer to designate at least one person with experience and expertise to evaluate the section under review. As part of the compliance audit, the employer must consult with operators with expertise and experience in each process audited, and must document the findings and recommendations from these consultations in the written report. The report must state the qualifications and identity of the persons performing the compliance audit.	The employer is required to consult with operators who have expertise and experience in each process that is audited, and document the findings and recommendations. This is necessary to ensure that the audit includes the line-level knowledge of operations in the practical application of running a unit.
WAC 296-67-371(3)	This is necessary to provide an avenue for employees to communicate concerns or

A requirement has been added that directs the refinery employer to make the audit report available to employees and employee representatives. The employer must respond in writing within sixty days to any written comments submitted by an employee or employee representative regarding the report.	suggestions regarding the content of the Compliance Audit to the employer.
WAC 296-67-371(4) A requirement has been added that directs the refinery employer to implement all recommendations pursuant to WAC 296-67-383 Corrective action program.	This is necessary to ensure that recommendations are implemented in a timely manner.
WAC 296-67-371(5) A requirement has been expanded that directs the refinery employer to retain the three most recent compliance audit reports.	This is necessary because the Compliance Audit reports need to be available for future reference to compare report recommendations over time and assess improvement between audits
Process Safety Culture Assessment	**The purpose of a PSCA is to assess key elements of a refinery's safety culture, identify strengths and weaknesses, implement corrective actions, and reassess progress. The adopted requirements establish a uniform PSCA performance standard for meeting this objective. The resulting information will form the basis for a refinery to improve its safety culture over time.**
WAC 296-67-375(1) A requirement has been added that directs the refinery employer to develop, implement and maintain an effective process safety culture assessment (PSCA) program.	This information is necessary for employers and employees to identify safety culture improvements and evaluate safety culture in the refinery.
WAC 296-67-375(2) A requirement has been added that directs the refinery employer to perform an effective PSCA and produce a written report within eighteen months following the effective date	This requirement is necessary to ensure that the process safety culture of a refinery is evaluated on an ongoing basis, in order to identify areas for improvement and allow course corrections to the program. The time

of Part B of this chapter, and at least every five years thereafter. If the employer has performed and documented a PSCA up to eighteen months prior to the effective date of Part B of this chapter, and that PSCA includes the elements required in this section, that PSCA may be used to satisfy the employer's obligation to complete an initial PSCA.	limits were established through stakeholder input.
WAC 296-67-375(3) A requirement has been added that directs the refinery employer to develop and implement by a team that must include at least one member knowledgeable in refinery operations and at least one employee representative. The team must consult with at least one employee or other individual(s) with expertise in assessing process safety culture in the petroleum refining industry.	This requirement is necessary to ensure the analysis is comprehensive and adequately addresses the regulatory requirements.
WAC 296-67-375(4)(a)-(d) A requirement has been added that directs the refinery employer to evaluate the effectiveness of the following elements of process safety leadership: The employer's hazard reporting program; The employer's response to reports of hazards; The employer's procedures to ensure that incentive programs do not discourage reporting of hazards; The employer's procedures to ensure that process safety is prioritized during upset or emergency conditions.	This is necessary to assess the effectiveness of the employer's hazard-reporting system, which allows employees to: report hazards anonymously; assess the effectiveness of the employer's hazard-reporting system in responding in writing (within 30 calendar days) to written hazard reports; have a prompt response to process safety hazards; and ensure the employer's incentive programs do not discourage hazard reporting This is necessary to ensure safety is prioritized in all instances, particularly during upset or emergency conditions.
WAC 296-67-375(5)(a)-(c) A requirement has been added that directs the refinery employer to develop a written report within ninety calendar days of completion of the PSCA, which must include: The method(s) used to perform the PSCA; the findings and conclusions of the PSCA; and	These requirements are necessary to ensure transparency and accountability.

the team's recommendations to address the findings of the PSCA.	
WAC 296-67-375(6) A requirement has been added that directs the refinery employer to consult with the PSCA team to identify and prioritize corrective actions that will be implemented within 24 months.	This is necessary to ensure that the employer implements high priority safety culture recommendations in a timely manner.
WAC 296-67-375(7) A requirement has been added that directs the refinery employer to perform a written interim assessment of the implementation and effectiveness of each PSCA corrective action within three years following the completion of a PSCA report. If a corrective action is found to be ineffective, the employer must implement changes necessary to ensure effectiveness within, but not to exceed, six months.	This is necessary to ensure that employers make course corrections when areas requiring improvement are identified.
WAC 296-67-375(8) A requirement has been added that directs the refinery employer to designate the refinery manager or designee as signatory to all PSCA reports, corrective action plans, and interim assessments.	This ensures accountability and transparency.
WAC 296-67-375(9) A requirement has been added that directs the refinery employer to communicate, and make available, PSCA reports, corrective action plans and interim assessments to all employees, their representatives, and participating contractors within sixty calendar days of completion.	This is necessary to ensure transparency and accountability.
WAC 296-67-375(10) A requirement has been added that directs participating contract employers to provide	This is necessary to ensure transparency and accountability for contractors and their employees.

PSCA reports, corrective action plans, and interim assessments to their employees and employee representatives within fourteen calendar days of receipt.	
Human Factors	**The federal OSHA National Emphasis Program for Refineries included Human Factors as one of the 12 core elements of an effective PSM program. The adopted requirements ensure that Human Factors are assessed with other process safety risks.**
WAC 296-67-379(1) A requirement has been added that directs the refinery employer to develop, implement and maintain an effective written human factors program within eighteen months following the effective date of Part B of this chapter. The adopted requirements ensure that Human Factors are assessed with other process safety risks.	Human Factors analysis provides an understanding of human capabilities, limitations and needs in relation to refinery operations and incident prevention, and prioritizes safety in the design of machines, operations, and work environments.
WAC 296-67-379(2) A requirement has been added that directs the refinery employer to include a written analysis of human factors, where relevant, major changes, incident investigations, PHAs, MOOCs, and HCAs. The analysis must include a description of the selected methodologies and criteria for their use.	This is necessary because a major change presents an opportunity to make substantial improvements in a refinery process. Major changes that include an effective Human Factors analysis promote employee safety and the safety of a process.
WAC 296-67-379(3) A requirement has been added that directs the refinery employer to assess human factors in existing operating and maintenance procedures and must revise these procedures accordingly. The employer must complete fifty percent of assessments and revisions within three years following the effective date of Part B of this chapter, and one hundred percent within five years.	This is necessary to provide the employer with flexibility in completing the required analysis.

WAC 296-67-379(4)(a)-(i) A requirement has been added that directs the refinery employer to apply an effective method for evaluating at least the following: Staffing levels; complexity of tasks; length of time needed to complete tasks; level of training, experience and expertise of employees; human-machine and human-system interface; physical challenges of the work environment in which the task is performed; employee fatigue and other effects of shiftwork and overtime; communication systems; and the understandability and clarity of operating and maintenance procedures.	Each of the elements in this list affects both the employee and the process; each element therefore can be improved through an effective Human Factors analysis. The analysis might reveal, for example, that reduced staffing can lead to excessive overtime, which can lead to fatigue and stress, which can reduce employee alertness and effectiveness, particularly if the employee is required to respond to an upset or emergency condition on the process. Likewise, communications systems must be designed to function effectively under the actual conditions that employees experience in the work environment. A Human Factors analysis would reveal whether a communication system is understandable in the noisy conditions of a refinery or the operation of portable radios is overly cumbersome, which could make them difficult to manipulate in an emergency.
WAC 296-67-379(5)(a)-(c) A requirement has been added that directs the refinery employer to include the following in the analysis: Error-proof mechanisms; automatic alerts; and automatic system shutdowns.	A poorly designed automatic alert that is intended to signal an upset condition on a process—but that is difficult for employees to visualize or interpret—will markedly reduce the effectiveness of the alert. Similarly, error-proof mechanisms are engineered to allow an action only when the system is in a safe condition. These mechanisms prevent employees from taking inappropriate actions, which can occur if an employee is fatigued, poorly trained, operating outside his or her area of expertise, or under time pressure. An effective Human Factors analysis will identify process control scenarios where error-proof mechanisms may be needed.
WAC 296-67-379(6) A requirement has been added that directs the refinery employer to include an assessment of	This requirement is necessary to ensure that the employer integrates a Human Factors analysis into all new operating procedures. A human factors analysis is necessary to ensure

human factors in new and revised operating and maintenance procedures.	that operating procedures are understandable and effective. Effective procedures are essential for both employee and process safety.
WAC 296-67-379(7) A requirement has been added that directs the refinery employer to train affected employees in the written human factors program.	This requirement is necessary to ensure that employees understand how human factors affect workplace safety and health and the safety of the process. Operating and maintenance employees represent a majority of employees involved in refinery processes and contribute to this analysis as part of team requirements.
WAC 296-67-379(8) A requirement has been added that directs the refinery employer to make available, and provide upon request, a copy of the written human factors program to affected employees and their representatives, including affected contractors, employees of contractors, and contractor employee representatives.	Involving employees in the human factors program is necessary to ensure that the analyses conducted under the program are current and relevant to a refinery's current process conditions. This expertise is best provided by employees who work on a process on a regular basis and who understand its operating and maintenance conditions.
Corrective Action Program	**The purpose of this section is to establish standardized procedures and timelines for refinery employers to prioritize process safety recommendations and implement corrective actions. This provision also ensures that there is a process for tracking all recommendations, criteria for rejecting recommendations, and requirements to document completion of corrective actions.**
WAC 296-67-383(1)(a)-(f) A requirement has been added that directs the refinery employer to develop, implement and maintain an effective written corrective action program to prioritize and implement recommendations of: Process hazard analyses (PHAs); safeguard protection analyses (SPAs); damage mechanism reviews (DMRs); hierarchy of hazard controls analyses (HCAs);	This is necessary to ensure that recommendations are prioritized and implemented in a timely and consistent manner throughout the PSM program.

incident investigations; and compliance audits.	
WAC 296-67-383(2) A requirement has been added that directs a refinery employer's team performing an analysis, review, investigation, or audit to provide findings and associated recommendations to the refinery employer in a timely manner.	This is necessary to ensure that the employer is made aware of process safety hazards and remedial recommendations as soon as possible.
WAC 296-67-383(3)(a)-(c) A requirement has been added that allows the refinery employer to reject a team recommendation if the employer can demonstrate in writing that the recommendation meets one of the following criteria: The analysis upon which the recommendation is based contains material factual errors; the recommendation is not relevant to process safety; or The recommendation is infeasible; however, a determination of infeasibility must not be based solely on cost.	This is necessary to provide a framework of accountability for decision-making by the employer regarding team recommendations
WAC 296-67-383(4) A requirement has been added that allows the refinery employer to change a team recommendation if the employer can demonstrate in writing that an alternative measure would provide an equivalent or higher order of inherent safety. The employer may change a team recommendation for a safeguard if an alternative safeguard provides an equally or more effective level of protection.	This requires the employer to demonstrate in writing that an alternative measure would provide an equivalent or higher level of inherent safety. This is necessary to ensure that solutions that offer less protection are not used in place of more protective measures.
WAC 296-67-383(5) A requirement has been added that directs the refinery employer to document all instances where any one of the criteria in subsection (3)	This subsection requires the employer to document and retain a record of all instances in which a team recommendation is rejected or changed. This is necessary to ensure

or (4) of this section is used for the purpose of rejecting or changing a team recommendation.	transparency and accountability in the implementation of team recommendations.
WAC 296-67-383(6) A requirement has been added that directs the refinery employer to communicate each recommendation that is changed or rejected by the employer to onsite team members for comment and made available to offsite team members for comment. The employer must document all written comments received from team members for each changed or rejected recommendation. The employer must document a final decision for each recommendation and must communicate it to onsite team members and make it available to offsite team members.	This requirement is necessary to ensure that each member of a PSM team is aware of, and able to comment on, any recommendation that the employer has elected to change or reject. This ensures transparency and accountability in addressing team recommendations.
WAC 296-67-383(7) A requirement has been added that directs the refinery employer to develop and document corrective actions to implement each accepted recommendation. The employer must assign a completion date for each corrective action and a person responsible for completing the corrective action.	This is necessary to ensure transparency and the employer's accountability for the health and safety of employees.
WAC 296-67-383(8) A requirement has been added that subjects PHAs, SPAs, HCAs, or DMRs to corrective action requirements. The refinery employer must promptly append all revalidated PHAs, SPAs, DMRs, and HCAs to the applicable report.	This is necessary to ensure that these analyses are current and are used to improve process safety.
WAC 296-67-383(9) A requirement has been added that directs the refinery employer to promptly complete all corrective actions and must comply with all completion dates required by this section. The	This is necessary to ensure information transparency and the employer's accountability for the health and safety of employees.

employer must perform an MOC for any adopted change to a completion date, pursuant to WAC 296-67-355 Management of change. The employer must make all completion dates available, upon request, to all affected employees and employee representatives.	
WAC 296-67-383(10) A requirement has been added that directs the refinery employer to complete all corrective actions within thirty months after the completion of the analysis or review, unless the employer demonstrates in writing that it is infeasible to do so.	This is necessary to establish a reasonable timeframe for implementing recommendations. The timeline for this subsection was determined through the stakeholdering and other input that Cal OSHA received during their rulemaking.
WAC 296-67-383(11) A requirement has been added that directs the refinery employer to complete a compliance audit within eighteen months after completion of the audit, unless the employer demonstrates in writing that it is infeasible to do so. Each corrective action from an incident investigation must be completed within eighteen months after completion of the investigation, unless the employer demonstrates in writing that it is infeasible to do so.	This is necessary because recommendations made from a compliance audit vary in terms of analysis and implementation.
WAC 296-67-383(12) A requirement has been added that directs the refinery employer to complete corrective actions requiring a process shutdown during the first regularly scheduled turnaround of the applicable process, following completion of the PHA, SPA, DMR, HCA, MOC, compliance audit or incident investigation, unless the employer demonstrates in writing that it is infeasible to do so.	This is necessary to ensure that applicable corrective actions are completed as soon as possible with the refinery's turnaround schedule.
WAC 296-67-383(13)	This is necessary to establish the prioritization of process safety hazards because the risks

A requirement has been added that directs the refinery employer, notwithstanding (10), (11), and (12), to promptly address process safety hazards through corrective actions either through permanent corrections or interim safeguards sufficient to ensure employee safety and health, pending permanent corrections.	posed by these hazards could result in a major incident or employee injury.
WAC 296-67-383(14)(a)-(d) A requirement has been added that directs the refinery employer to ensure that interim safeguards are sufficient to ensure employee safety and health, pending permanent corrections. The employer must document the decision and rationale for any delay and must implement the corrective action as soon as possible. The documentation must include: The rationale for deferring the corrective action; All MOC requirements; A revised timeline describing when the corrective action will be implemented; and An effective plan to make available the rationale and revised timeline to all affected employees and their representatives.	These requirements are necessary because failing to implement a corrective action in a timely manner could adversely affect process safety. Some permanent corrective actions require time to complete. Interim measures are necessary to have in place until permanent corrections are completed to ensure the health and safety of employees. The requirements allow the employer to demonstrate in writing the rationale for failing to meet the specified time limits, while ensuring that the employer implements the permanent correction in accordance with the revised timeline.
WAC 296-67-383(15) A requirement has been added that directs the refinery employer to track and document the completion of each corrective action and must append the documentation to the applicable PHA, SPA, DMR, HCA, incident investigation or compliance audit.	This is necessary to track the employer's performance in meeting the required implementation timelines. This ensures information transparency and the employer's accountability for the health and safety of employees.

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CHAPTER 7: APPENDIX

A.1 Gas Price Impact Analysis

When there is a refinery shutdown, the full cost of that event to consumers is the sum of the direct and indirect costs. However, most of the price hike is captured as increased profits by the other refiners that continue to produce during the disruption.[144] Thus, the direct cost of the price increase is a transfer from consumers to producers and is not considered a net societal cost. We estimate the societal cost of the price increase by the consumer's portion of the deadweight loss in fuel markets (i.e. the net value of the missed purchases of fuel by consumers). Because demand for transportation fuels are very inelastic, particularly in the short run, this measure of cost is significantly smaller than the overall cost impact of the price increase. Additionally, gasoline, diesel, and jet fuel accounted for approximately 43%, 23%, and 14% respectively of the dollar value of output of Washington refineries during the period considered.[145] Because the necessary data to estimate price impacts was only available for gasoline, the impact on other fuels would be inferred.

Market prices are determined by the interaction between supply and demand-side factors. Market factors at the national level are incorporated into average U.S. fuel prices, while the impact of region specific market factors are averaged out. To control for local factors, we include year and month fixed effects in the model specification. The year fixed effects are intended to control for demand factors, supply factors, and policy factors, such as the level of regulation and taxation, that differ between Washington State and the U.S. on average. Monthly fixed effects were included to control for seasonal changes in fuel markets that are relatively consistent from year to year. The regression model for predicting prices was:

$$P_{WA,t} = \alpha + \beta_1 P_{US,t} + \sum_{k=2}^{K} \delta_k Y_k + \sum_{i=2}^{12} \gamma_i M_i + \epsilon_t$$

[144] Gonzales et al, 2016.
[145] WRC (2012), Washington Research Council," The Economic Contribution of Washington State's Petroleum Refining Industry In 2011: Table A.2 Quantity and Value of Output," Aug. 2012, available at: http://researchcouncil.org/wp-content/uploads/2012refineryreportfinal040913.pdf

Where

- $P_{WA,t}$ is average weekly retail price for gasoline in Washington at for week *t;*
- $P_{US,t}$ is the U.S. average weekly retail price for gasoline at for week *t;*
- Y_k is indictor for the year;
- M_i is an indicator for the month of the year;
- α , β_1, δ_k (k = 2007,…,2012), γ_i (i= 2,…,12) are parameters to be estimated;
- And, ϵ_t is a normally distributed stochastic term.

Steps for estimating deadweight loss to society:

1. Estimate weekly Washington fuel prices for the counterfactual situation of no refinery shutdown using the regression model.
2. Calculate the difference between actual fuel prices and counterfactual fuel prices to estimate the increase in weekly prices resulting from the shutdown.
3. Sum the product of the estimated weekly price impact (increase) and observed weekly sales[146] over the period of disruption to estimate the direct cost to consumers.
4. Estimate the weekly reduction in sales resulting from the increase in price using the elasticity of demand and the estimated price impact.
5. Calculate the aggregated deadweight losses (indirect cost) to the society using the estimated price impact and sales impact in each week (t):

$$DWL=\sum_{t=1}^{T} 0.5 * Price\_change * sales\_change$$

A.2 Washington Refinery Deaths Compare to National Level

EHS today reported on an exhaustive search by *The Texas Tribune* and the *Houston Chronicle* of all U.S. refinery deaths occurring between 1995 and 2015. Their search, which "included OSHA records, government investigation reports, newspaper archives and legal filings," identified 137 confirmed deaths during the period. Because refineries use a significant number of contractors

[146] Source: EIA.gov

who are indirectly employed, relying only on official records of refinery deaths may underestimate the number worker deaths.[147]

Based on the incident descriptions provided in the report, we separated the reported deaths into "natural deaths" such as a heart-attack occurring in the workplace and "unnatural deaths" which resulted from a workplace incident. We further identified likely process safety related deaths based on the keywords: fire, explosion, release, chemical exposure, hydrogen sulfide exposure, and asphyxiation. Some of the incidents involved multiple fatalities, so we also identified the total number of incidents. The results are presented in Table A2.1. In total there were 92 process safety related deaths in U.S over that period of time, 15 of which occurred in Washington refineries. The 16.3% share of total process safety related deaths for Washington refineries was significantly higher than their share of total U.S. refining capacity (3.7%).

Table A2.1: Refinery Deaths in U.S. and WA (1995 to 2015)[148]

	Total Deaths	Natural Deaths	Unnatural Deaths	Total Incidents
Total in U.S.	137	7	130	96
Likely process safety related in U.S.	92	0	92	52
Washington Total	16	1	15	4
Washington process safety related deaths as % of U.S. total	16.3%			

According to EIA, there was an average of 147 operable refineries in the U.S. and five in Washington during the period of 1996-2020.[149] This would translate to a frequency of 0.03 annual process safety related deaths per refinery nationwide and 0.1 annual deaths for Washington. Again, Washington refining industry owned a much higher death rate than national average.

[147] Malewitz, J. 2015, "A Deadly Industry," EHS Today, Mar 31, 2015. Available at https://www.ehstoday.com/safety/article/21916835/a-deadly-industry
[148] Source: Malewitz (2015).
[149] EIA.gov.

A.3 Refinery Incidents in the U.S.

A.3.1 Process Safety Events in the U.S.

In 2010, the American Petroleum Association (API) developed process safety event (PSE) indicators described as "Recommended Practice (RP) 754, Process Safety Performance Indicators for the Refining and Petrochemical Industries." The second edition was published in April of 2016. API's RP 754 divides PSE indicators in several tiers. Tiers 3 and 4 are considered leading indicators of process safety in a facility and are intended for internal use to assess performance of process safety programs. Tiers 1 and 2 are considered lagging indicators and involve unplanned or uncontrolled releases of any material, including non-toxic and non-flammable materials from a process that results in one or more consequences defined by API's RP 754.[150] Release of more severe consequences are considered Tier 1, while Tier 2 is assigned to lesser consequence release. Consequences are cataloged in the Appendix of that document (Table A.1: Process Safety Event Consequences). Tier 1 and Tier 2 events are voluntarily reported by participating refineries and summary statistics for annual PSEs are published by the API. Table below summarizes reported PSE occurring in 2014-2018.

Table A3.1: U.S. Refining PSE Summary[151]

	2014	2015	2016	2017	2018	5-Year Average
Number of companies	25	32	32	29	31	30
Number of refineries	85	95	96	92	100	94
Refinery capacity response rate[152]	87%	90%	89%	85%	95%	89%
Tier 1 PSEs reported	118	147	84	101	94	109
Tier 1 PSEs reported per refinery	1.39	1.55	0.88	1.10	0.94	1.16
Tier 2 PSEs reported	319	290	260	253	280	280
Tier 2 PSEs reported per refinery	2.70	1.97	3.10	2.50	2.98	2.57

[150] API, 2010. American Petroleum Institute. "Recommended Practice 754: Process Safety Performance Indicators for the Refining and Petrochemical Industries, Fact Sheet," March 2010.
[151] Source: API, 2015, 2016 and 2019.
[152] Source: EIA Refinery Capacity Report; 2014-2017 revised using capacities published in the EIA Refinery Capacity Report for the given survey year.

Based on the number of PSEs reported by the API, there was an average of 1.16 Tier 1 PSEs per facility annually nationwide between 2014 and 2018. Assuming Washington State refineries are consistent with the national average, we would expect one or more incidents per year per refinery. Major Refinery Incidents like those analyzed in Section 4.2 or more severe incidents occur less frequently.

A.3.2 Recent High Profile Refinery Events

High profile refinery events provide a context for the severity of the consequence a catastrophic refinery incident could cause. Three incidents occurred in Texas, Wisconsin, and Pennsylvania are illustrated as examples here. These are all federal OSHA jurisdiction states.[153] and have a similar PSM standard to Washington.

(1). BP Texas City, Texas (March 23, 2005)

The BP Texas City refinery explosion was one the most severe incidents since the OSHA PSM and EPA RMP standards were adopted. The incident involved 15 worker deaths, 66 worker hospitalizations and 110 workers treated for minor injuries (EPA, 2016; CBA). The value of lost human life using a Value of Statistical Life of $9.4 million would be around $141 million. According to Marsh Report (2018), property damage to the 460,000 BPD facility was $200 million (2005 dollars). The combined cost of repairs to the facility and lost profits were estimated at around $1 billion in 2008, and the amount paid in compensation topped $2 billion (Bergin. T, 2008). Some of the lost profits and compensation costs represent transfers to other parties and thus do not represent net changes in social welfare; however, there are also likely unquantified or qualitative costs, such as environmental harms and other costs borne by the public that are not incorporated in the figure. The production capacity of the Texas City refinery is more than three times that of the average refinery in Washington State.

(2). Husky Superior Refinery, Wisconsin (April 2018)

On April 26, 2018, an explosion and subsequent fire occurred in the Fluid Catalytic Cracking Unit (FCCU) of the 40,000 BPD Husky Superior refinery. Thirty-six people received medical

[153] https://www.osha.gov/stateplans/

treatment, including 11 refinery workers. The fire resulted in a day-long evacuation of residents of the proximate community (CSB, 2018). As a result of the damage, the refinery was completely shut down and reconstruction of the refinery began in the fall of 2019. It is expected to become fully operational in late 2022 and the latest estimate of rebuilding cost for the refinery was $1.2 billion, around three times the original estimate.[154] Additionally, as a result of the explosion, a significant amount of petroleum product was released. The production capacity of the Husky Superior refinery is similar to that of the U.S. Oil & Refining company refinery in Tacoma, Washington, illustrating the potentially high cost of incidents at even small refineries.

(3). Philadelphia Energy Solutions, Girard Point Refinery, Pennsylvania (June 2019)

The PES refinery incident began when a corroded pipe elbow ruptured in the refinery's alkylation unit and released process fluid. The release lead to a fire and explosion and the release of 5,000 pounds of hydrofluoric acid. Five workers suffered minor injuries and required first aid treatment, but no residents were injured in the incident. Insured losses resulting from the incident were estimated to be as high as $1.25 billion[155]; while the Marsh Report estimated that the property damage along with debris removal and clean-up costs totaled $750 million (2019 dollars).[156] The company ultimately filed for bankruptcy, laying off more than 1,000 workers.[157] Emergency response to the fire was an initial deployment of 120 firefighters and more than 50 pieces of equipment, while hazardous material crews remained on site for nearly three months. PES agreed to pay the city of Philadelphia $1.8 million in reimbursement for its emergency response efforts.[158]

A study conducted in 2017, prior to the refinery explosion, used an input/output model to estimate the regional economic impact of a hypothetical permanent shutdown of the Philadelphia Refining Complex.[159] They estimated that a permanent closure would affect more than 10,000

[154] "Cost to rebuild burned Superior oil refinery keep growing," April 27, 2022, Star Tribune.
[155] Insurance Journal, 2020.
[156] Marsh JLT Specialty, 2020.
[157] Hussein, F, 2019, "Refinery Explosion Probe Zeroes In on Acid Use, Corroded Pipe," Bloomberg Environment, Oct. 16, 2019.
[158] Maykuth, A., 2020, "A Philly refinery will repay the city for emergency response costs from last year's fire and explosion," The Philadelphia Inquirer, April 17, 2020, available at: https://www.inquirer.com/business/energy/pes-refinery-fire-bankruptcy-city-philadelphia-firefighting-cost-20200417.html.
[159] Dismukes, D. E. & G. B. Upton, Jr., 2017. "Economic Impact and Re-Employment Assessment of PES Philadelphia Refining Complex," Acadian Consulting Group, August 31, 2017.

jobs, reduce annual labor income by $1 billion, contract the economy by $2.4 billion in value added, and result in the loss of $175 million in tax revenue for the region. Although the study did not consider social welfare effects of the facility shutdown, the results are suggestive of size of the impact on the local economy.

A.4 Survey of Economic Impact of Adopted Washington Process Safety Management Rule for Petroleum Refineries

INTRODUCTION:

The purpose of this survey is to estimate both new costs and benefits your business may incur due to the new and amended requirements in the adopted Process Safety Management rule for petroleum refineries. Your answers are very important for us to accurately estimate the economic impact of the adopted rule on affected businesses.

There are 16 sections in this survey:

- **Section 1**: General Overview
- **Section 2:** Process Safety Management Program
  - **2.1** Performance Indicators
- **Section 3**: Employee Collaboration
- **Section 4**: Process Safety Information
- **Section 5:** Process Hazard Analysis,
  - **5.2:** Safeguard Protection Analysis
  - **5.3:** Hierarchy of Hazards Controls Analysis
- **Section 6:** Operating Procedures
- **Section 7:** Training
- **Section 8:** Pre-Startup Safety Review
- **Section 9:** Mechanical Integrity (& RAGAGEP)
- **Section 10:** Damage Mechanism Review
- **Section 11:** Management of Change
- **Section 12:** Management of Organizational Change
- **Section 13:** Incident Investigation & Root Cause Analysis
- **Section 14:** Process Safety Culture Assessment
- **Section 15:** Human Factors
- **Section 16:** Corrective Action Program.

Each section includes the Washington State Department of Labor & Industries' internal cost estimates for significant components of the rule, including contracting costs. Annual average costs are estimated over ten years, and are presented in terms of 10,000 barrels per calendar day (bpd) of production capacity. Costs of corrective actions resulting from the various analyses required under the adopted rule (e.g. PHAs, HCAs, etc.) are attributed to the Corrective Action Program.

Please answer the questions the best you can. If you do not have the exact information, use your best estimate.

Per RCW 42.56.070(19), information gathered under chapter 19.85 RCW (Regulatory Fairness Act) or RCW 34.05.328 (Significant Legislative Rules) that can be identified to a particular business is exempt from public disclosure.

Section 1: General Overview Questions

1. In qualitative terms, how many additional resources do you think your company will need to meet the new PSM requirements? **Please indicate the answer that best describes your refinery's situation.**

☐ No additional resources required. We are meeting virtually all of the requirements already.

☐ Marginal additional resources required. We are doing many of the things required, but will need to adjust them somewhat and/or report them differently.

☐ Significant additional resources required. We will need to hire people, buy equipment, and redesign processes, etc. in order to meet the adopted regulatory requirements.

☐ Major additional resources required. We will have to make big changes and completely restructure our safety regime.

2. Does your refinery break out PSM costs from other refinery operations or production costs?

☐Yes ☐No

If you break out this cost, about how much do you spend CURRENTLY on the PSM related activities each year? ***Please estimate to the nearest $100,000.***

3. Based on internal research, our preliminary estimate is that the ADOPTED rule will create NEW costs ranging from **$104 thousand to $1.12 million per year, per 10 thousand bpd** of capacity over a ten-year period (e.g. a refinery with an average capacity of 125 thousand bpd would incur costs of **$1.3 million to $13.9 million per year)**

Do you estimate that your costs of complying with the ADOPTED rule will significantly differ from this range?

☐Yes ☐No

If yes, please provide an estimate of the expected compliance cost for your facility.

4. How confident are you in the cost estimates given in response to the prior questions? Please indicate the answer that describes your confidence level.

☐ Not very confident.
☐ Somewhat confident. Significant uncertainty regarding cost.
☐ Confident. Informed estimate.
☐ Very confident. Data-driven analysis.

5. What is the production capacity of your refinery measured in barrels per calendar day?

Section 2: Process Safety Management Program -WAC 296-67-311

1. Do you currently use the program management approaches required by the adopted rule?
☐Yes ☐No

If no, please describe the ways in which your current program is similar and the ways in which it differs.

2. Please estimate the annual costs of your CURRENT program management, in terms of personnel and other costs.

3. Internal estimate of compliance cost under the ADOPTED rule:

- Employers are estimated to utilize 120-160 hours of manager's time to revise their written program to cover new requirements, incurring a one-time cost of approximately $15,000 -$20,000 per refinery.
- Updating the written program is estimated to require 20 hours of manager's time every three years, costing $830 annually per refinery.
- *Note: Program management costs arising from other provisions are attributed and counted in those specific sections.*

Do you estimate that your cost of complying with these requirements will significantly differ from this range? ☐Yes ☐No

If yes, please detail how they will differ.

4. How much additional cost would you expect to incur under this ADOPTED rule? Please indicate whether each source of additional cost is a one-time upfront cost or recurring annual cost.

5. Please describe any potential cost savings associated with the revised program management procedures under the adopted rule.

Section 2.1: Process Safety Performance Indicators -WAC 296-67-311(4)

1. Do you currently have a program for tracking and reporting process safety performance indicators (PIs)?

☐Yes ☐No, skip to question 4.

2. Please estimate the costs of your CURRENT program for tracking and reporting performance indicators in terms of personnel and other costs.

3. Will your current PI program satisfy the requirements of the adopted rule?

☐Yes ☐No

If not, please estimate the additional costs that would be incurred in terms of personnel, consulting, and other costs to comply with the ADOPTED rule. Indicate whether each source of cost is a one-time upfront cost or is a recurring annual cost.

4. Internal estimate of compliance cost under the ADOPTED rule:

- We estimate that establishing a new program for tracking PIs will require 440-550 hours of engineering time, and incur one-time costs in the range of $42,000 - $52,600 per refinery.
- We estimate that tracking and reporting PIs will create additional ongoing labor burden of 96-120 hours of engineering time annually, and will incur costs of $9,200 - $11,500 annually.
- Overall, we estimate the PI requirement will add **$1,100 -$1,400 per 10,000 bpd** in annual costs.

Do you estimate that your cost of complying with these requirements will significantly differ from this range? ☐Yes ☐No

If yes, please detail how your costs will differ.

5. Please describe any cost savings associated with the new performance indicator tracking and reporting processes in the adopted rule.

Section 3: Employee Collaboration - WAC 296-67-315

1. Do you anticipate that your program for employee collaboration (participation) will significantly change under the adopted rule?

☐Yes ☐No

If yes, please describe how the program will change and estimate the costs associated with the change. Indicate whether the additional costs are one-time or recurring.

2. Internal estimate of compliance cost under the ADOPTED rule:

- We estimate that revision of the written employee collaboration plan, the development of stop work authority (SWA) procedures, and employee training for SWA will require 270-464 labor hours and incur one-time costs of $18,700 - $29,500 per refinery.
- Employee collaboration will also add initial and ongoing costs to various other PSM elements. These costs will be attributed and counted in those specific sections.

Do you expect your cost of complying with these requirements to differ significantly from this cost range?

☐Yes ☐No

If yes, please detail how they will differ.

3. How frequently has your refinery experienced unplanned downtime over the past ten years?

4. How long (in approximate number of days) did these unplanned downtime events last?

5. What was the approximate percentage of refinery capacity lost in each incident?

Section 4: Process Safety Information -WAC 296-67-319

1. Will you need to develop or revise process safety information (PSI) for any processes not previously covered by PSM?

☐Yes ☐No

If yes, please estimate the total costs of developing PSI for these processes in terms of personnel costs, costs of consultant services, and other costs.

2. Internal estimate of compliance cost under the ADOPTED rule:

- Development of a program for integrity operating windows and the review and compilation of RAGAGEP for PSI are estimated to require 212-380 labor hours per refinery and incur initial costs of $12,000 - $21,000.
- We estimate that developing new PSI requires 450-2,200 labor hours per process and costs $29,000 - $199,000.
- Overall, the adopted rule would create annual costs of **$600 - $10,700 per 10,000 bpd** of capacity over a ten year period.

Do you expect your cost of complying with these requirements to significantly differ from our estimates?

☐Yes ☐No

If yes, please detail how your costs differ.

Section 5: Process Hazard Analysis -WAC 296-67-323

1. Internal estimate of PHA costs under the CURRENT rule:

- We estimate that initial PHA(s) require 680 – 1,100 labor hours to complete and cost $63,000 - $105,000 per process.
- Revalidations of PHAs in compliance with the current rule are estimated to require 340-550 labor hours and cost $31,000 - $53,000 per process.
- Corrective actions resulting from initial PHAs are estimated to require average capital expenditures of $75,000 -$105,000 per process.

Do your costs of conducting PHAs under the CURRENT rule significantly differ from our estimates?

☐Yes ☐No

If yes, please detail how your costs differ.

2. Will your costs of conducting new PHAs or revalidating existing PHAs for a process change under the new rule? ☐Yes ☐No

If yes, please describe how the cost of PHAs will change and whether the additional costs are one-time or recurring costs?

3. Are there any processes not previously not covered by PSM that would require new initial PHAs to comply with the adopted rule?

☐ Yes, approximate number_____ ☐ No

4. Internal estimate of PHA costs under the ADOPTED rule:

- Considering the new elements that must be included in PHAs as well as the revised employee collaboration requirement in the adopted rule, we estimate that initial PHA(s) for a process will require 850 – 1,360 labor hours to complete and cost $72,000 - $118,000 per process.
- Revalidations of PHAs are estimated to require 424-678 labor hours and cost $36,000 - $59,000 per process.
- Excluding the cost of corrective actions, we estimate that the revised PHA requirement will add annual costs of **$6,800 - $21,400 per 10,000 bpd** of productive capacity.
- *Note: We include costs estimates for corrective actions in the corrective action program.*

Do you estimate that your cost of complying with these requirements will significantly differ from this range? ☐Yes ☐No

If yes, please detail how your costs differ.

5. Please estimate the costs associated with conducting the new PHAs in terms of personnel costs, costs of consultant services, and other costs. Indicate whether each source of cost is a one-time upfront cost or recurring annual cost.

6. Please estimate the costs of implementing recommendations resulting from new PHAs. Indicate whether each source of cost is a one-time cost or recurring annual cost.

Section 5.2: Safeguard Protection Analysis - WAC 296-67-323(2)

1. Do you currently do Layer of Protection Analyses (LOPA) or some other form of Safeguard Protection Analysis (SPA)?

☐Yes ☐No if no, skip to 7.

2. Do you currently do SPAs in a way that would meet the requirements of the adopted rule?

☐Yes ☐No, if no

3. How frequently do you currently conduct SPAs? Do you have a formal schedule for revalidation of SPAs?

4. Please estimate the annual costs of your current SPA procedure, in terms of personnel and other costs (excluding corrective actions). Indicate whether each cost is a one-time or recurring annual cost.

5. If your facility currently does SPAs, please describe typical corrective actions that follow SPA recommendations, along with the associated costs.

6. Would your procedures for doing SPAs change under the new requirements?

☐Yes ☐No,

If yes, please explain how they would change.

7. Internal estimate of compliance cost under the ADOPTED rule:

- We estimate that program development for SPAs will require 280-560 labor hours and incur a one-time cost of $22,900 - $46,000 per refinery.
- We estimate that initial SPAs for a process will require 92-405 labor hours and cost $7,300 -$32,100.
- Revalidations of SPAs are estimated to require 46-202 labor hours and cost $3,600 - $16,000 per process.
- Excluding the cost of corrective actions, we estimate that the new SPA requirement will add annual costs ranging from **$1,100 to $6,000 per 10,000 bpd** of productive capacity.
- *Note: We include costs estimates for corrective actions in the corrective action program.*

Do you estimate that your cost of conducting SPAs as required by the ADOPTED rule will significantly differ from this range? ☐Yes ☐No

If yes, please detail how your estimated costs differ.

8. How much new SPA work (expressed in terms of cost) would you estimate doing under the adopted rule? Indicate whether each source of additional cost is a one-time upfront cost or recurring annual cost.

9. Please describe corrective actions that you anticipate resulting from SPAs, along with the associated costs.

10. Please describe any cost savings associated with the SPA requirement and the actions that follow recommendations.

Section 5.3: Hierarchy of Hazard Control Analysis –WAC 296-67-323(3)

1. Do you currently do hierarchy of hazard controls analyses (HCAs) or a related method of inherently safer systems design (ISS/D) analyses?

☐Yes ☐No, skip to question 8.

2. Do you currently have a written program for conducting HCAs?

☐Yes ☐No

3. About how many HCAs do you currently do each year?

4. Do you conduct HCAs in all circumstances required by the adopted rule?

☐Yes ☐No

If no, please describe the situations in which HCAs are conducted.

5. Please estimate the total annual costs of current HCAs, in terms of personnel and other costs.

6. Please describe typical corrective actions (e.g. increased inspection frequency, repairs, or replacements/infrastructure costs) that follow HCA recommendations. Please estimate the costs of the actions.

7. Would your procedures for doing HCAs change under the new requirements?

☐Yes ☐No

8. Internal estimate of HCA compliance costs under the adopted rule:

- We estimate that developing a new program for conducting HCAs would require 720 – 960 labor hours and incur one-time costs of $57,400 – $76,600 per refinery.
- We estimate that 'stand-alone' HCAs for new or existing processes and HCAs resulting from 'major changes' will require 144-816 labor hours and cost $12,400 -$74,000 per HCA.
- Revalidation of HCAs are estimated to require 72–408 labor hours and cost $6,200 - $37,000 per process.
- HCAs originating from PHAs or incident investigations, which are narrower in scope, are estimated to require 20-144 total labor hours and have costs of $1,500 - $12,500 per HCA.

- Excluding the costs of corrective actions, we estimate that compliance with the HCA provision of the adopted rule will add annual costs of **$12,000 - $602,000 per 10,000 bpd** of capacity.
- *Note: We include costs estimates for corrective actions in the corrective action program.*

Do you estimate that your cost of conducting HCAs as required under the ADOPTED rule will significantly differ from this range?

☐Yes ☐No

If yes, please detail how your estimated costs differ.

9. How many HCAs would you estimate doing annually under this adopted rule?

10. Please provide program cost estimates for a single HCA, broken out by staffing costs, contractor costs, equipment costs, and other costs.

11. Would the typical actions that follow HCA recommendations change under the new requirements? Please describe the costs associated with these changes.

12. Please describe any cost savings that may result from HCA procedures and the actions that follow the recommendations.

Section 6: Operating Procedures -WAC 296-67-327

1. Will you need to develop or revise operating procedures for any processes not previously covered by PSM?

☐Yes ☐No

If yes, please estimate the total costs of developing operating procedures for these processes in terms of personnel costs, costs of consultant services, and other costs.

2. Internal estimate of compliance cost under the ADOPTED rule:

- The development of operating procedures for newly covered processes is estimated to require 126-140 labor hours and cost $10,000 - $11,000 per process.
- Annual updates of operating procedures are estimated to require 24-26 hours per process and cost $1,700 - $1,800.
- Overall, we estimate that the adopted rule will add annual costs of **$400 - $1,300 per 10,000 bpd** of capacity.

Do you expect your cost of complying with these requirements to significantly differ from our estimates?

☐Yes ☐No

If yes, please detail how your costs differ.

Section 7: Training -WAC 296-67-331

1. Do you expect the adopted rule to prompt significant changes in your training programs?

☐Yes ☐No

If yes, please describe the nature and estimated costs of these changes. Please indicate whether these costs are one-time or recurring costs.

2. Internal estimate of compliance costs under the ADOPTED rule:

- We estimate that revision of process safety training programs will require 500-644 labor hours and involve initial costs of $44,500 - $57,600 for the average refinery in Washington.
- Affected operators and maintenance employees are estimated to receive 24-40 of initial process safety training and 9-16 hours of refresher training every three years.
- We estimate that the revised training requirements for maintenance employees will add initial costs of $80,000 - $134,000 for the average refinery and ongoing annual costs of $12,000-$21,000.
- Employees of contractors are estimated to receive 16-24 hours of initial process safety training.
- We estimate that the revised training requirements for affected contractors will add one-time costs of $344,000 - $516,000 for the average refinery.
- Overall, we estimate that refineries will incur additional annual costs of **$5,300 - $8,200 per 10,000 bpd.**

Do you estimate that your cost of complying with these requirements will significantly differ from this range?

☐Yes ☐No

If yes, please detail how your estimated costs differ.

Section 8: Pre-startup Safety Review -WAC 296-67-339

1. About how many pre-startup safety reviews (PSSRs) do you currently conduct each year?

2. Please estimate the cost of a typical PSSR under the current rule in terms of personal and other costs.

3. Will your procedures for PSSRs significantly change under the adopted rule?

☐Yes ☐No

If yes, provide a brief explanation.

4. How many PSSRs do you anticipate doing each year under the adopted rule?

5. Internal estimate of compliance costs under the ADOPTED rule:

- We estimate that each PSSR will require 24-72 labors hours to conduct and will incur costs of $1,500 - $4,700.
- Compliance with the revised PSSR requirement is estimated to cost an additional **$2,500 - $15,400 per 10,000 bpd.**

Do you estimate that your cost of conducting PSSRs as required under the ADOPTED rule will significantly differ from this range?

☐Yes ☐No

If yes, please detail how your estimated costs differ.

Section 9: Mechanical Integrity –WAC 296-67-343

1. Does your current Mechanical Integrity (MI) program meet the requirements of the adopted rule?

☐Yes ☐No

If not, explain what changes you will need to make to comply.

2. Do you have a process for evaluating new or updated codes and standards and implementing (internal or external) RAGAGEP changes?

☐Yes ☐No

3. Please estimate the costs of changes to your (internal or external) RAGAGEP and/or MI programs. Please indicate whether these costs are one-time or recurring costs.

4. Internal estimate of compliance costs under the ADOPTED rule:

- We estimate that development of a written program for updating codes and standards and implementing RAGAGEP will require 96-160 labor hours and incur a one-time cost of $7,300 -$12,200 per facility.
- We estimate that refineries will expend 1,344 – 3,840 labor hours annually and incur annual costs of $96,000 - $275,000 to comply with **(343)(5)(f).**
- We estimate that bringing newly covered processes into compliance with MI will require initial costs of $2,500 -$5,400 per process and recurring annual costs of $16,000 - $120,000 per process.
- Overall, we estimate that the MI requirements in the adopted rule will add annual costs of $**8,800 - $68,100 per 10,000 bpd** of capacity.

Do you estimate that your cost of complying with these requirements will significantly differ from this range?

☐Yes ☐No

If yes, please detail how your estimated costs differ.

Section 10: Damage Mechanism Review -WAC 296-67-347

1. Do you currently conduct Damage Mechanism Reviews (DMRs)?

☐Yes ☐No , skip to question 7.

2. Do you currently do DMRs for all processes and circumstances covered in the adopted rule?

☐Yes ☐No

If not, please describe the situations in which DMRs are conducted.

3. How many DMRs do you currently do each year on average?

4. Please estimate the total annual costs of current DMR procedures, in terms of personnel and other costs.

5. Please describe typical actions that follow DMR recommendations and the associated costs. Please indicate which costs are one-time costs and which are recurring costs.

6. Would the typical actions that follow DMR recommendations change under the new requirements?

☐Yes ☐No

Please describe the costs associated with these changes. Please indicate which costs are one-time costs and which are recurring costs.

7. Internal estimate of compliance costs under the ADOPTED rule:

- We estimate that developing a new written program and methodology for conducting DMRs will require 280-560 labor hours and incur a one-time costs of $23,000 - $46,000 per refinery.
- We estimate that conducting an initial DMR for an entire process will require 160-560 labor hours and cost $15,000 - $52,500 per process.
- Revalidations of DMRs for processes are estimated to require 80-280 labor hours and cost $7,500 - $26,300.
- Excluding the cost of corrective actions, we estimate that compliance with the DMR provision will add annual costs of **$2,100 - $67,400 per 10,000 bpd** over a ten year period.
- *Note: We include costs estimates for corrective actions in the corrective action program.*

Do you estimate that your cost of conducting DMRs as required under the ADOPTED rule will significantly differ from this range? ☐Yes ☐No

If yes, please detail how your estimated costs differ.

8. Please provide program cost estimates for a single "typical" DMR, broken out by staffing costs, contractor costs, and other costs. Please indicate which costs are one-time costs and which are recurring costs.

9. How many DMRs would you estimate doing annually to comply with the adopted rule?

10. Please describe any cost savings associated with the DMR process and the actions that follow the recommendations.

Section 11: Management of Change –WAC 296-67-355

1. About how many management of change reviews (MOCs) do you currently conduct on an annual basis?

2. Please estimate the total annual costs of current MOC procedures, in terms of personnel and other costs.

3. Will your procedures for MOCs significantly change under the adopted rule?

☐Yes ☐No

If yes, provide a brief explanation

_____

4. How many MOCs do you anticipate doing each year under the adopted rule?

5. Internal estimate of compliance costs under the ADOPTED rule:

- We estimate that revision of written Management of Change (MOC) procedures will require 16-24 labor hours and incur one-time costs of $2,000 - $3,000 per refinery.
- Under the new requirements, MOCs for newly covered processes are estimated to require 122-217 labor hours and cost $9,000 - $16,000.
- We estimate that adopted revisions to MOC requirement will create additional annual costs of **$9,900 – $130,000 per 10,000 bpd** over a ten year period.

Do you estimate that your cost of conducting MOCs as required under the ADOPTED rule will significantly differ from this range? ☐Yes ☐No

If yes, please detail how your estimated costs differ.

Section 12: Management of Organizational Change –WAC 296-67-359

1. Do you currently have written procedures to manage organizational changes?

☐Yes ☐No

2. Will your current procedures need to be modified to comply with the rule?

☐Yes ☐No

If yes, explain how your procedures will change.

3. Given your understanding of the adopted rule, how many MOOC assessments would you expect to conduct annually?

4. Internal estimate of compliance costs under the ADOPTED rule:

- We estimate that developing a written program for Management of Organizational Change (MOOC) will require 90-120 labor hours and incur an initial cost of $6,700 - $9,000 per refinery.
- Each MOOC analysis will require an estimated 145-242 labor hours and cost $12,100-$20,200.
- Overall, we estimate that compliance with the MOOC provision will add annual costs of **$250 - $400 per 10,000 bpd** over a ten year period.

Do you estimate that your costs of conducting MOOCs as required under the ADOPTED rule will significantly differ from this range? ☐Yes ☐No

If yes, please detail how your estimated costs differ.

Section 13: Incident Investigation --Root Cause Analysis -WAC 296-67-363

1. Taking the last three years as representative, about how many incident investigations do you currently conduct each year to comply with the PSM rule?

2. Given your understanding of the adopted rule, how many additional incident investigations do you anticipate conducting? _____

3. Please estimate the total annual costs of current incident investigation procedures, in terms of personnel and other costs.

4. Do you currently include root causes analysis (RCAs) as part of your incident investigation procedures? ☐Yes ☐No, skip to question 10.

5. For what type of incidents or events do you conduct RCAs?
_____

6. Please provide program cost estimates for a single RCA, broken out by staffing costs, contractor costs, and other costs.

7. Please describe typical actions that follow RCA recommendations and provide estimates of the associated costs.

8. Would your procedures for doing RCAs change under the new requirements?
☐Yes ☐No

If yes, describe how they would change.
_____

9. Would the typical corrective actions that follow RCA recommendations change under the new requirements? Please describe the costs associated with these changes.

10. Internal estimate of compliance costs under the ADOPTED rule:

- We estimate that developing a new written program for conducting root cause analyses (RCAs) and training affected personal will require 1,080-1,880 labor hours and incur a one-time cost of $73,000 - $129,000 per refinery.
- We estimate that complying with the RCA requirement will increase the labor burden of each incident investigation by 54-157 hours and add costs of $4,500 - $16,000 per investigation.

- Excluding the costs of corrective actions and other recommended analyses, we estimate that the requirement to conduct RCAs for all investigations involving 'process safety incidents' will add annual costs of **$5,900 - $63,000 per 10,000 bpd** of capacity.
- *Note: The cost of corrective actions is estimated with the corrective action program.*

Do you estimate that your cost of conducting RCAs as required under the ADOPTED rule will significantly differ from this range?

☐Yes ☐No

If yes, please detail how your estimated costs differ.

11. Please describe any cost savings associated with the RCA process and the actions that follow the recommendations.

Section 14: Process Safety Culture Assessment –WAC 296-67-375

1. Do you currently conduct process safety culture assessments (PSCAs) at your facility?
☐Yes ☐No, skip to question 7.

2. Do you have a written PSCA program? ☐Yes ☐No

3. Do you currently do PSCAs using methods and frequency that would comply with the adopted rule? ☐Yes ☐No

If not, briefly explain what would need to change.

4. Please estimate the total annual costs of current PSCAs, in terms of personnel and other costs.

5. Please describe typical actions and associated costs that follow the production of a safety culture report and action plan (e.g. increased training, restructuring of management systems or procedures). Please indicate which costs are one-time costs and which are recurring costs.

6. Would your procedures for doing PSCAs change under new requirements? ☐Yes ☐No

If yes, briefly explain what would need to change.

7. Internal estimate of compliance costs under the ADOPTED rule:

- We estimate that developing a new PSCA program and methodology as well as training employees will require 4,836 - 6,188 labor hours and incur a one-time initial cost of $558,000 - $856,000 per refinery.
- Ongoing costs from performing a PSCA and developing a report every five years, implementing a corrective action plan, and developing an interim written assessment are estimated to require 310-446 labor hours annually and incur cost of $24,800 - $36,800 per refinery.
- Overall, we estimate that the PSCA requirement will add annual costs of **$7,000 - $10,700 per 10,000 bpd** of capacity.

Do you estimate that your cost of conducting PSCAs as required under the ADOPTED rule will significantly differ from this range?

☐Yes ☐No

If yes, please detail how your estimated costs differ.

8. Please describe any cost savings associated with the PSCA process and the actions that follow the recommendations.

Section 15: Human Factors -WAC 296-67-379

1. Do you currently conduct human factors (HF) analyses at your facility?

☐Yes ☐No, skip to question 7.

2. Do you currently have a written human factors program?

☐Yes ☐No

3. If you have such a program, does it meet all of the requirements of the adopted rule?

☐Yes ☐No

If no, briefly describe how it differs.

4. Please estimate the annual costs of your current human factors program, in terms of personnel and other costs.

5. Please describe typical actions that follow human factors analyses and provide estimates of the associated costs.

6. Would your procedures for assessing and managing human factors change under the new requirements? ☐Yes ☐No

If yes, briefly describe how it would change.

7. Internal estimate of compliance costs under the ADOPTED rule:

- We estimate that developing a new human factors program and training affected personnel will involve 2,462 – 4,008 labor hours and incur a one-time cost of $164,000 - $251,000 per refinery.
- An initial HF analysis for a process is estimated to require 176-648 labor hours and cost $12,700 - $50,100 per process.
- Revisions of operating and maintenance procedures resulting from HF analyses are estimated to require 24-160 labor hours and cost $1,600 – $12,200 per process.
- Excluding costs of corrective actions, we estimate that the adopted human factors requirement will add annual costs of **$2,900 - $10,700 per 10,000 bpd** of capacity.
- *Note: Cost of corrective actions estimated with the corrective action program.*

Do you estimate that your cost of complying with the human factors requirement under the ADOPTED rule will significantly differ from this range? ☐Yes ☐No

If yes, please detail how your estimated costs differ.

8. How much new human factors work (expressed in terms of cost) would you estimate is required under the ADOPTED rule?

9. Would the typical actions that follow human factors analysis change under the new requirements? Please describe the cost associated with these changes and indicate which costs are one-time costs and which are recurring costs.

10. Please describe any cost savings associated with the human factors process and the actions that follow recommendations.

Section 16: Corrective Action Program –WAC 296-67-383

1. Do you currently have a written corrective action program to implement the recommendations of PHAs, incident investigations, and/or other related analyses?

☐Yes ☐No

2. Will your current corrective action program require any changes to meet the requirements of the adopted rule?

☐Yes ☐No

If yes, please describe how it would change

3. Internal estimate of compliance cost under the ADOPTED rule:

- We estimate that developing a new corrective action program will require 1,280-2,160 labor hours and incur a one-time initial cost of $144,000 - $295,000 per refinery.
- Ongoing annual costs of administering the program are estimated to be 288-384 labor hours and $25,700 - $34,400 per refinery.
- New annual costs of corrective actions resulting from all analyses required by the propose PSM rule are estimated to be **$49,000 - $104,000 per process** for the first five years and **$24,000 - $52,000 per process** in subsequent years.
- Including both the costs of administering the corrective action program and implementing recommended corrective actions, we estimate new annual costs of **$34,000 - $95,000 per 10,000 bpd** of capacity over a ten year period.

Do you estimate that your cost of complying with the corrective action requirement under the ADOPTED rule will significantly differ from this range? ☐Yes ☐No

If yes, please detail how your estimated costs differ.

4. Please estimate the additional costs that would be incurred in terms of personnel, consulting services, and other costs. Please indicate whether each cost is a one-time upfront cost or recurring annual cost.

Overall

How confident are you in the cost and cost saving estimates given in response to the prior questions? Please indicate the answer that describes your confidence level.

- ☐ Not very confident.
- ☐ Somewhat confident. Significant uncertainty regarding costs and or cost savings.
- ☐ Confident. Informed estimate.
- ☐ Very confident. Data-driven analysis.