IMPROVED MANAGEMENT OF MAJOR SHUTDOWNS AT TRAIL OPERATIONS

by

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PROJECT SUBMITTED IN PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF BUSINESS ADMINISTRATION

In the Executive MBA Program
of the
Faculty
of
Business Administration

SIMON FRASER UNIVERSITY

Spring 2011

Approval

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Abstract

The KIVCET and the zinc roaster plants at Trail perform major maintenance shutdowns to ensure safe and reliable production. These events are very resource intensive and have a significant impact on production. Previous shutdowns have resulted in significant safety, hygiene, and environmental difficulties. Effective management of these events is important to the success of Trail Operations. In this paper, I analyze existing practices to identify some of the major problems that impede performance. I then provide a number of recommendations to improve shutdown management at Trail based on recognized best practice. This paper concludes with an implementation plan that is performed by shutdown practitioners and plant management, working under the guidance of a senior level steering committee.

To Angelica, my wife and friend for life

For her encouragement, patience and cheerful laugh

Praise God for the blessing she is

Acknowledgements

I would like to thank Teck for sponsoring the MBA program with Simon Fraser University. It was a privilege and a please to gain new insights into our business, our communities and the world we live in. I am also very thankful to all my classmates who made the past three years so interesting. It was fun to get to know you, and to work with you.

I would like to acknowledge the helpfulness of the many people at Trail Operations who gave me valuable input for this project. I also wish to express my gratitude to Dr. Ian McCarthy for his patience, guidance and encouragement with this project. It has become stronger and more focused because of his suggestions.

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1: Introduction

Teck Metals Ltd. operates one of the world's largest fully integrated zinc and lead smelting and refining complexes in Trail, British Columbia. Major maintenance shutdowns are required at the KIVCET lead smelter and the zinc roaster plants to achieve safe and reliable production. These shutdowns are very resource intensive and have a significant impact on production. Previous shutdowns have resulted in major safety, hygiene and environmental difficulties that have prompted subsequent improvements to shutdown management practices at Trail.

This paper examines the current state of shutdown management in both areas through the full shutdown management cycle of planning, execution and follow-up. This paper identifies the important role of the equipment integrity teams at the smelter, and demonstrates their significant contribution to achieving improved shutdown performance. The paper summarizes shutdown management practices and identifies problems and opportunities.

Based on this situation, I recommend establishing a common approach to shutdown management under the guidance of a steering committee, with specific solutions implemented by shutdown practitioners and plant management. I present an implementation plan for achieving best practice using concepts for effective organizational transformation defined by Kotter (2007).

To achieve these aims, the paper is structured as follows. Chapter 2 reviews and analyzes current shutdown practices at Trail, and identifies key issues to address. Chapter 3 presents recommendations to address the issues identified. Chapter 4 uses the Kotter (2007) model to explain how to implement the recommendations.

2: Shutdown Maintenance at Trail

This chapter provides a review and analysis of existing shutdown maintenance activities at the Trail metallurgical facility. This review introduces the reader to the shutdown management process and highlights performance gaps. The final section identifies and substantiates four major problems impeding shutdown management performance at Trail.

2.1 Trail Overview

Trail Operations, located in British Columbia, is one of the world's largest fully integrated zinc and lead smelting and refining complexes. The metallurgical operations produce refined zinc and lead as well as sixteen additional products including precious metals, specialty metals, chemicals and fertilizer products. Ongoing high transportation costs associated with Trail's inland location, and high labor costs, have resulted in a high focus on efficient operating practices to ensure economic operation.

Maintenance activities are a key component of ensuring economic operation by achieving high equipment availability and operating rates. Associated costs comprise a significant portion of the Trail Operations routine and capital budgets. Management of planned maintenance shutdowns comprises a significant component of the total site maintenance cost. Specifically, major shutdowns of the KIVCET furnace and the zinc roaster operations have significant impact to the bottom line for Trail Operations. Not only are these shutdowns costly in terms of direct costs, but there is the lost opportunity due to production downtime. A high level of planning and coordination is required to ensure maximum effectiveness of these shutdowns.

2.2 Types of Maintenance Shutdowns

Planned plant and equipment shutdowns are required to ensure safe and efficient operation. These shutdowns are categorized as opportunity shutdowns, minor maintenance shutdowns and major maintenance shutdowns. This section describes the primary purpose of each of these shutdowns.

Opportunity shutdowns are the most common type of shutdown and are of relatively short duration. These shutdowns are required to clean process equipment and provide a chance for the plant to perform specific preventative maintenance and minor mechanical repairs that require the plant to be out of service. A typical example is the need to clean the radiant section of the KIVCET boiler of accumulated accretions by micro blasting every six weeks. Similarly, the zinc plant has one of the four cell house units down for cleaning every six weeks. The leaching plant schedules opportunity maintenance concurrent with cell house cleaning. Duration of opportunity shutdowns varies from 12 hours to three days from one plant to another depending on specific requirements. Local contractors supplement regular maintenance crews to maximize these maintenance opportunities.

Minor maintenance shutdowns are larger in scope than opportunity shutdowns. Duration of minor maintenance shutdowns is typically four to six days. Minor shutdowns at the zinc roasters provide an opportunity to complete a full cleanout of the gas handling system. The zinc roasters and the lead smelter typically perform minor shutdowns once or twice every year. As with opportunity shutdowns, local contractors supplement the maintenance and service crews to minimize shutdown duration.

Major maintenance shutdowns are significantly larger in scope than opportunity or minor shutdowns. These events require a complete cleanout or drainage of process materials, and cool down of furnaces to acceptable workplace temperatures, before repair activity can start. Major maintenance shutdowns are routinely scheduled in the in the Lead Smelting (LS); and the Roasting and Sulphur Products (RSP) business areas as indicated in Table 2.1. These shutdowns are mandatory events based on boiler and pressure vessel regulations. Major shutdowns are extensive and include large projects that require full access to the process equipment. These large projects determine the overall shutdown schedule with all other maintenance activities subordinate to them. Typical shutdown projects include furnace rebuilds, major refractory repairs, and KIVCET boiler inspection and repair activities. The business area forms a management team for these shutdowns, with most of the work completed by contractors. The shutdown management team attempts to maximize the use of local contractors.

Table 2.1 Standard Major Maintenance Shutdowns at Trail Operations

	Duration (days)	Shutdown Interval (years)	Direct Cost (Cdn $million)	Lost Opportunity (Cdn $million)
LS: KIVCET	30 - 50	3	40 – 60	15 – 25
RSP: #10 Roaster	10 - 16	2	3 – 6	2 – 3
RSP: #20 Roaster	10 – 16	2	3 – 6	2 – 3
RSP: ZPL	10 – 20	2	2	2 – 3
RSP: Total	2	2-3	1	2

Source: author

2.3 Major Maintenance Shutdown Process

Each business area at Trail Operations provides preliminary five-year forecasts of upcoming major and minor shutdowns. This information forms the basic assumptions used in the five-year production forecasts for production and financial planning purposes. These forecasts also provide a general framework for overall shutdown coordination within Trail Operations. Within the one-year time horizon, the projects group regularly issues updated plant shutdown schedules.

Business area management has full accountability for the planning and execution of plant maintenance shutdowns. The full cycle of shutdown management includes scope identification, front-end engineering, detailed planning and preparation, shutdown execution, and follow-up. The following sections describe the scope and management process for each of these activities. The final section provides a case study demonstrating the important ongoing contribution of the smelter integrity teams makes to these shutdowns.

2.3.1 Shutdown Scope Identification

Defining shutdown scope is the first step in the shutdown management process. A high-level shutdown scope document is prepared. This document includes a listing of planned shutdown projects with primary objectives for each. Shutdown scope is prepared by analyzing equipment condition and performance against recognized regulatory and design standards. A forward look of predicted future equipment condition is required to ensure reliable operations.

The lead smelter has a strong focus on identifying shutdown scope as early as possible. Once a major shutdown is completed, the smelter begins to identify the scope for the next major shutdown based on recommendations contained in job post mortems and supplied by the smelter integrity teams. Shutdown job owners complete post mortems, identifying work not completed to original scope and identified additional work based on equipment inspections. Smelter integrity groups provide recommendations within six months of completing a shutdown based on a more detailed review of furnace and boiler condition. The boiler-integrity group recommendations include a recommended scope of work, as well as required timing for the next shutdown.

Once the lead smelter has developed its comprehensive shutdown scope and the timing for the next shutdown, plant management meets with Trail and corporate senior management groups to ensure understanding and endorsement of the shutdown plan at an early stage. These meetings are required because of the large direct cost and the significant production impact of KIVCET shutdowns. This communication has also proven to be helpful in ensuring the necessary support throughout the Trail and corporate organizations.

The roaster group identifies shutdown scope for the upcoming year as part of the budget planning cycle. Plant engineers define scope based on previously documented shutdown inspection results as well as regulatory requirements and input from plant personnel. This approach is highly dependent of the knowledge and skill of individual engineers.

Plant personnel in both areas define additional scope of work and projects for upcoming shutdowns during the course of routine plant operations. A systematic method of managing additions to shutdown scope in a controlled manner is required. In the smelter, the integrity groups manage this function; while in the roasters, plant management must approve any additions to scope.

2.3.2 Shutdown Front-End Engineering

Front-end engineering includes all activities required to build up the high-level scope items into work packages that the shutdown team can use to prepare for the next shutdown. Engineers work with plant operating and maintenance personnel, engineering supply and design companies, and contractors, to identify how to implement the identified shutdown projects, while ensuring adherence to regulatory and Teck internal standards.

In-plant engineering personnel lead the front-end engineering activities for all shutdown projects. They review available information and meet with plant personnel to develop a detailed project scope. The engineers then perform or outsource engineering activities to detail practical aspects of the work including equipment supply, materials and work procedures. The front-end engineers review proposed plans with subject matter experts to ensure they address the original project objectives. Following this, they perform risk assessments with mitigating strategies identified to address high hazard issues. These activities culminate in preparation of a work package that include budget cost, schedule, scope, resource requirements, material specifications, procurement activities, quality assurance requirements, work procedures, and risk mitigation for each job.

Typically, there is more than sufficient time available to complete shutdown front-end engineering activities; however due to other duties for the engineers, this activity often becomes a bottleneck in the shutdown management process. Both the smelter (Marsh, 2011) and the roaster organizations have identified this difficulty. This became less critical for the smelter in 2010 due to the decision to defer the shutdown from April to October. The roaster organization has created and uses a simple spreadsheet to track front-end engineering activities against key milestones, and enables management intervention to occur in a timely manner. The roaster organization would benefit by earlier shutdown scope definition.

2.3.3 Shutdown Planning and Preparation

Shutdown planning and preparation includes the activities required to compile shutdown work packages, plant maintenance, and utility requirements into a shutdown team ready to manage and coordinate all shutdown activities. This includes defining the organizational team, communication and reporting structures, procurement, schedule, overall budget, cost controls, and detailed work plans.

At the smelter, the shutdown manager manages planning and preparation. This individual is a member of the Trail Projects group and manages execution of the portfolio of major projects in the lead business units between shutdowns. While managing these projects, he allots about 10 to 20% of his time to prepare for the next major shutdown. He ensures specific requirement are recognized and well defined. The incumbent provides necessary influence to ensure front-end engineering and major procurement activities stay on track.

The smelter shutdown manager meets with the lead-smelter operating manager a year prior to the shutdown to establish the final scope of work for the shutdown, including input from the utility groups. The shutdown scope of work, together with information contained in the work packages form the basis for determining the specific shutdown organizational structure, the overall shutdown project schedule, and total shutdown budget cost. The shutdown organizational structure is then used to select individual team members for various roles based on demonstrated experience and potential employee development opportunities.

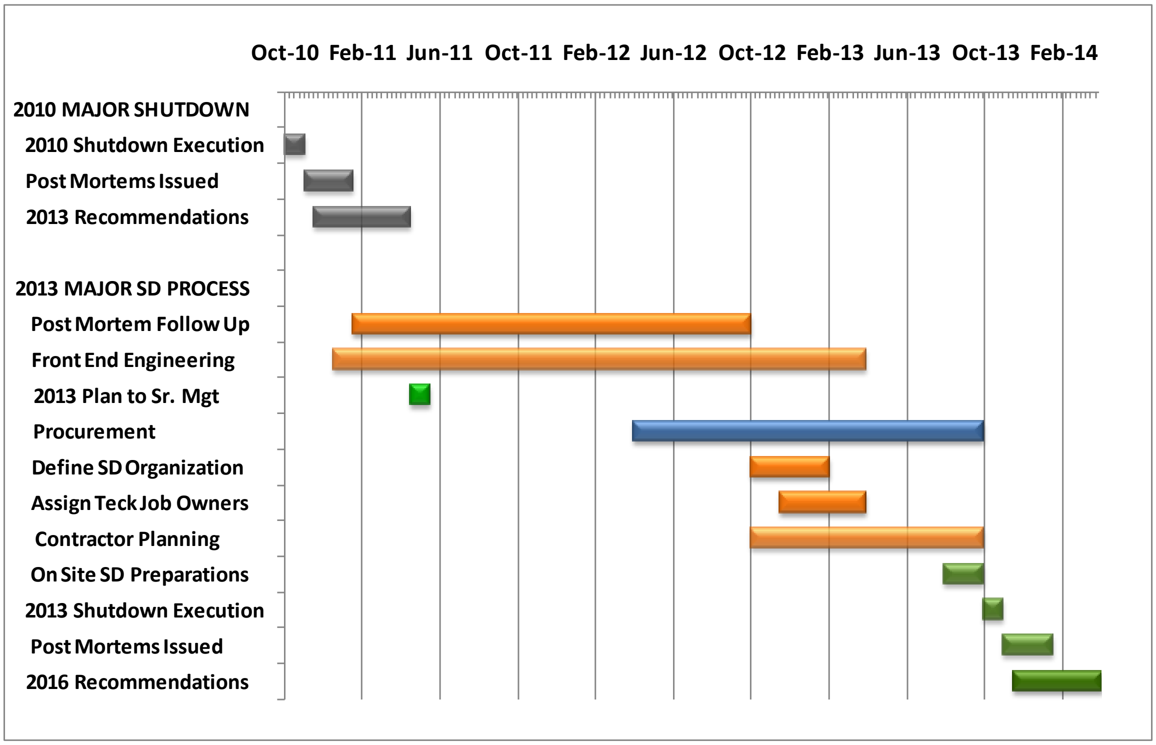
With the organizational structure in place, the shutdown manager defines specific roles and associated responsibilities for each position in a formal document. All shutdown team members receive training to ensure a common understanding of the identified roles and responsibilities. The smelter shutdown manager schedules additional skill training to ensure all shutdown personnel are fully capable of working to defined expectations.

Job owners receive work packages developed by the front-end engineers. Job owners work with smelter personnel to identify specific shutdown project requirements. Plant personnel then prepare detailed procedures for plant shutdown, equipment isolations and preparations, and start-up requirements. Strong systems are in place to complete comprehensive hazard risk assessments (HRA) for all aspects of every project. Overlapping hazards with other projects are resolved at this stage. This information is provided to contractors who build on this information to develop detailed safe work plans, schedules, and budgets.

Normally this approach has provided satisfactory results; however, this was not the case in 2010. Safety, health and environmental specialists were not available in a timely manner (Marsh, 2011) to provide necessary input to the planning process. This caused a significant delay in providing necessary safety requirements to contractors, and thus they had very little time to prepare safe work plans for their employees. There was insufficient contractor involvement in the shutdown planning process (Kniel, 2010). A better approach is to ensure contractors routinely participate in the Teck risk assessment process to build a common understanding of the significant risks and to develop safe work plans based on practical experience.

Contractor capacity to develop their detailed safe work plans is variable. Contractors well familiar with specific jobs began work with weak safe work plans (Marsh, 2011). The shutdown management team assesses contractor capacity following each shutdown to assist in determining which contractors to work with in subsequent shutdowns. An important challenge is to build local contractor capacity to achieve optimum shutdown performance while minimizing shutdown costs. This is also an effective contribution to the local economy.

Figure 2.1 Typical KIVCET Planning and Execution Cycle for Major Shutdowns



Source: author

The Trail purchasing group works with the smelter shutdown manager to develop procurement plans. Monthly meetings begin about one year prior to the shutdown to identify critical procurement needs. The purchasing group prepares and maintains a master procurement list visible to all to ensure transparency on deliveries. Sufficient time is available to allow for competitive bidding; negotiation of terms and conditions for risk management purposes; discounts for early payment; elimination of restocking fees; and optimization of transportation arrangements. An estimated 5% cost saving is achieved by effective integration of the purchasing department in the smelter shutdown planning process. An essential deliverable of shutdown procurement activities is to ensure all materials arrive on time to meet shutdown requirements. This process has resulted in a significant improvement in on-time delivery for shutdown materials.

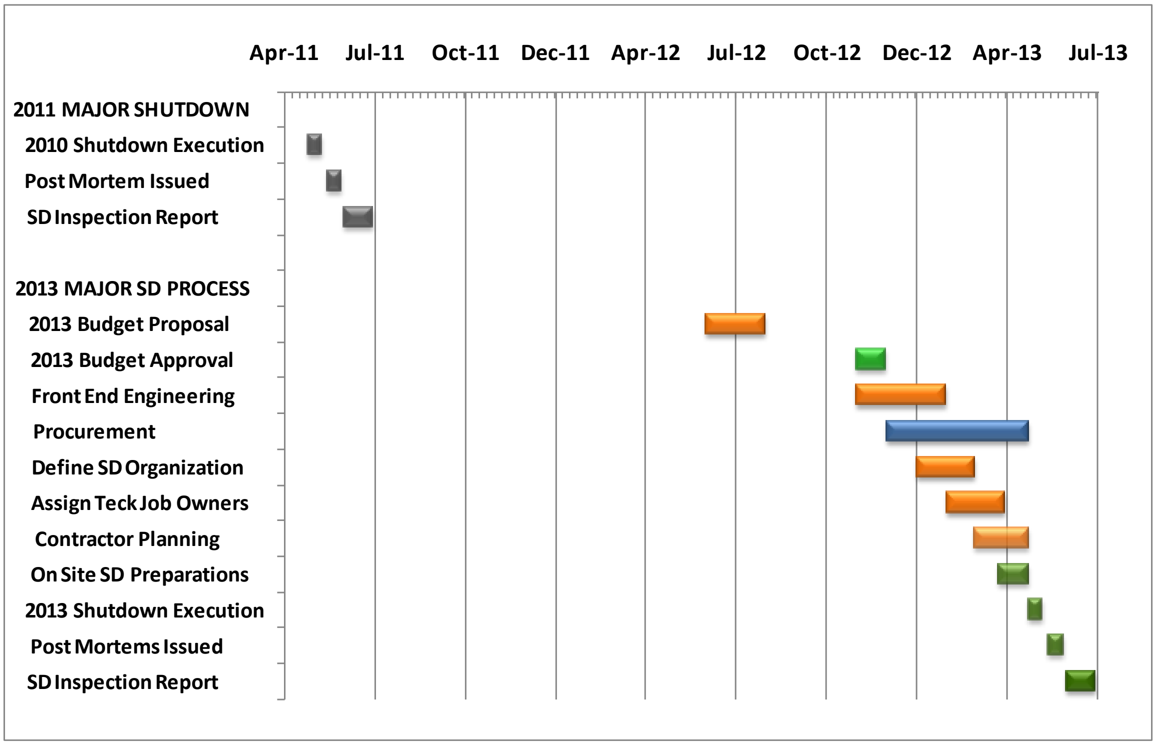
Many small maintenance activities require the plant to be shutdown; however, the planning process for these activities is very different from the large shutdown projects. The smelter maintenance group plans these jobs within the constraints imposed by the major shutdown project and identifies requirements for supplemental personnel. The smelter maintenance superintendent reports to the smelter shutdown manager during the major shutdown event.

With up to 800 shutdown contractors on-site everyday during the shutdown, detailed plans are developed for many activities including communications, employee inductions, security, parking, locker assignments and change rooms, supply of specialized personal protective equipment, on-site buses, lunchrooms, and janitorial services. Support groups recognize the importance of effective shutdown management and provide the necessary assistance to deliver the necessary support. When support groups are not able to provide necessary assistance, they identify these constraints in a timely manner and the shutdown team identifies alternative solutions.

The roaster organization applies a similar approach to shutdown planning and preparation; however, the scope of shutdown activities is much smaller and planning occurs in a much shorter period. The roaster shutdown coordinator functions as the shutdown manager for the major shutdowns. There is much less coordination with purchasing than occurs in smelter shutdowns. This leads to higher costs and more problems such as late delivery of shutdown supplies. Contractors participate in the hazard risk assessments with the job owners and front-end engineers when practical.

In 2009-10, the roaster maintenance group handed over responsibility for routine preventative and repair maintenance occurring during a shutdown to the roaster shutdown team. This lack of understanding of the difference between the nature of shutdown maintenance projects, and maintenance tasks occurring during shutdowns, resulted in overwhelming the shutdown planning process. Responsibility for routine maintenance occurring during the shutdown has returned to the roaster maintenance group.

Figure 2.2 Typical Roaster Planning and Execution Cycle for Major Shutdowns



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2.3.4 Shutdown Execution

Shutdown execution is the phase of shutdown management when the shutdown team implements the defined projects. This includes pre-shutdown site preparations, process shutdown, maintenance shutdown inspection and repair activities, process start-up and shutdown demobilization. The worksite becomes very active as numerous contractors come on site. Effective communication is essential to ensure all activities are well coordinated.

A robust reporting structure is required during shutdown execution. To support this requirement the shutdown manager reports directly to the lead-smelter operating manager during shutdown execution. The project manager has overall responsibility for the full scope of all shutdown activities. This responsibility begins when contractors start arriving on-site prior to the shutdown to set up temporary offices and to prepare the worksite for planned maintenance activities.

Effective communications are required during shutdown execution. A daily meeting with all job owners, essential operators and support staff ensures effective site coordination, management of overlapping hazards, and early identification of any problems. Job owners, crew supervisors and crews meet daily to establish effective coordination within each job or work area. The shutdown project manager meets daily with members of the Trail senior management group to provide a high-level status of projects and review site indicators of safety, health, environmental, cost and schedule performance. The shutdown team set up a SharePoint site for the 2010 smelter shutdown and achieved further improvement in the quality of information sharing between all groups.

The 2010 shutdown demonstrated a new level of quality management with checkpoints defined for each of the major projects. Quality assurance personnel were on site 24 hours a day (Marsh, 2011) to perform the necessary checks and give approval to proceed. This group inspected all deviations in equipment condition and initiated preparation of revised repair plans. This approach to quality ensured strong compliance to defined expectations and allowed job owners and contractors to focus on working to plan.

Strong systems are in place for cost tracking. A central cost centre receives all invoices on a daily basis and prepares a daily update of all indicated project costs by 10 o’clock every morning. Job owners review and approve all invoices and then provide daily updates of costs incurred to date and estimated final job cost. The shutdown manager reviews overall costs and trends on a daily basis and identifies any potential issues to senior management. This approach ensures a strong focus on cost management and avoids any surprise in total shutdown cost due to contractor delays in submitting invoices. Timely cost tracking also provides an additional benefit when working with contractors that provide discounts for early payment of invoices.

The roaster organization applies a similar approach to shutdown execution. Management ensures a strong focus on revisiting plans when there are differences between conditions defined in the safe work plans and actual conditions. For example, as soon as a potential mercury hygiene issue arose, management stopped work in the mercury removal tower for 81 hours while a thorough review of the work was completed. The roaster shutdown team has a significantly weaker focus on cost and schedule management than is present at the smelter. Few jobs have extensive quality assurance procedures.

2.3.5 Shutdown Follow Up

Shutdown follow up activities include site cleanup and evaluation of the shutdown experience. Waste disposal activities are essential to preventing future difficulties. An effective post mortem and a formal follow up process are important to achieving continuous improvement in shutdown performance.

Waste disposal is an area of difficulty for all areas. Waste disposal costs have typically not been included in scope of work for the shutdown projects (Marsh, 2011). Standards for disposing of mercury-contaminated wastes are unclear. There is no clear site ownership of shutdown waste management responsibilities.

Smelter job owners have a defined responsibility to perform job post mortems within two weeks of completion of work to ensure effective contractor input. The quality of the post mortems is variable depending on the skill level of each of the job owners and is an area for improved training in future shutdowns (Marsh, 2011). The shutdown project manager normally compiles a comprehensive post-mortem report.

The roaster organization prepares weak post mortems, and follow up often does not take place. The shutdown coordinator lists problems and successes as identified by the shutdown job owners; however, there is no analysis of root cause or identification of how to improve future performance. Roaster management attributes this deficiency to resource constraints, with several shutdowns each year at the roasters.

2.3.6 Process Equipment Integrity Groups

The lead smelter has formed two process integrity groups to improve asset management of the critical process equipment in response to significant events and equipment concerns. For example, the smelter established a boiler integrity group following the February 2004 explosion in the KIVCET furnace. These two groups provide technical oversight of the large furnaces and boilers in the business area. The following case study of the furnace integrity group illustrates how it contributes to improved smelter performance and shutdown management.

Smelter management established the KIVCET furnace integrity group in response to short operating campaigns between major shutdowns. Furnace hearth condition became a major worry when the site refractory expert identified a significant risk to the life of the furnace hearth because of frequent thermal cycles. This problem was caused by the annual major shutdown of the KIVCET furnace. He estimated that these frequent thermal cycles had reduced furnace heath life from the original design of twenty-five years to ten years. With an estimated cost of $35,000,000 and three-month duration to replace the furnace hearth, change was obviously required. The KIVCET integrity group began to meet on a monthly basis, to document and monitor furnace condition.

After meeting for some time the group set a goal of achieving a four-year operating campaign between major shutdowns. This was a major shift from the one-year operating campaign of that time. The group completed a detailed review of all furnace components, and identified potential risks to the four-year goal. They analyzed numerous options for overcoming these risks and developed a recommended approach to increase the length of the furnace operating campaign. Early analysis indicated that a four-year campaign would be extremely difficult to achieve. As a first step, the integrity group proposed the installation of an additional lead top-hole, and specific changes to furnace jacket design at critical locations. With these changes, the group proposed a three-year campaign as an interim target.

The KIVCET furnace now successfully achieves a three-year operating campaign between major shutdowns. Condition of the furnace boiler has become the primary constraint to achieving longer operating campaigns. Over time, the group has evolved to providing technical oversight of all four major furnaces in the lead smelting business area, and taking the lead on identifying scope of work for major shutdowns.

The furnace integrity group manages quality assurance during the smelter shutdown including detailed inspection of furnace components. One of the group members compiles all results and observations. They then meet following the shutdown to review this information and to recommend scope of work for the next shutdown. The group defines this shutdown scope within the two months of completing a major shutdown. For example, in 2010 the smelter shutdown was completed in November 2010, and before Christmas 2010 the group identified scope of work for the 2013 shutdown, and as well as a preliminary scope for the 2016 shutdown. With scope in place, front-end engineering for the 2013 shutdown started January 2010.

2.4 Shutdown Challenges

The previous sections have introduced the reader to the shutdown maintenance processes and practices at Trail. I will now identify and substantiate four major problems to resolve as the next step in improving shutdown management performance at Trail. The first two problems are specific to the roaster area, and the other two apply to all major shutdowns at Trail.

2.4.1 Roaster Shutdown Management Team Capacity

The shutdown management team at roaster organization lacks the necessary skills and experience to manage shutdowns to the expected standard for Trail Operations. Essential to a successful shutdown is effective management of workplace safety, environmental performance, cost and schedule. Shutdown results over the past two years demonstrate deficiencies in all these areas. This section highlights several examples demonstrating these deficiencies. The team members themselves are all capable and willing individuals; however, the team as a whole does not deliver the necessary results due to insufficient experience and inadequate training. Some examples also point to the need for stronger support in the area of health and safety management.

Teck has defined safety as a core value, believing that all incidents are preventable. Safety in the workplace is a guiding principle for Trail Operations “We commit to everyone going home safe and healthy every day.” The company has set safety targets of less than 2.1 reportable incidents and less than 0.5 lost time incidents per 200,000 hours worked. Major roaster shutdowns in 2009 and 2010 have not achieved this level of performance. The shutdown team did not calculate safety statistics for these shutdowns and thus the author has calculated these statistics based on readily available information in order to compare results against company targets.

The October 2009 shutdown of #10 Roaster and #9 Acid Plant had three reportable incidents, two of which resulted in lost time. Based on a daily count of contract workers and a typical ten-hour working shift, estimated contractor hours worked during the October 2009 shutdown is 12,400. Safety statistics calculated from this information indicate 48.4 reportable incidents, including 32.3 lost time incidents per 200,000 hours worked. These results were well in excess of the company targets.

The first safety incident in the 2009 shutdown occurred on the first day of the shutdown. Strong sulphuric acid sprayed onto the face and neck of a pipefitter while he was installing isolation blinds. This contractor was off work for several weeks because of this incident and was fortunate not to lose his eyesight. The identified cause of this incident was inadequate plant procedures to prepare this line for isolation. Recent changes in requirements for process equipment isolation had established a requirement to install the blind, and there had been no review of potential impacts of this change. The root cause of this incident is the ineffective implementation of new job procedures by an inexperienced shutdown management team.

The second serious injury was a worker receiving lacerations to his hand due to use of a “cheater bar” on a socket wrench. This worker received stitches for the injury and then returned to work. The root cause of this incident was the failure of the contractor to work to its own defined safe work procedures. Contributing to this incident was the lack of training for the Teck job owner. He was not aware of his responsibilities and had not taken adequate steps to prevent this incident.

The third incident was a worker fracturing three toes due to a large precipitator collector plate falling onto his foot. The contractor did not recognize the potential hazard associated with corrosion at the plate attachment points and thus did not implement preventive measures. The Teck job owner had not completed an HRA for this job prior to the shutdown. This incident was caused by ineffective shutdown management by a job owner who did not did not understand the full scope of his responsibility.

The shutdown post mortem for the October 2009 shutdown identified that job owners did not complete expected job safety audits everyday as expected. This was a disturbing finding, especially in light of the very serious incident at the start of the shutdown and a daily reminder to all job owners of this requirement. The shutdown manger did not hold job owners accountable to meet this standard during the course of the shutdown. The root cause of this problem was an inexperienced shutdown manager not fully aware of his responsibilities.

The October 2010 shutdown of #20 Roaster and #9 Acid Plant had two reportable incidents based on a listing of individual incidents. Reportable incidents included a worker with a dislocated finger due to falling off stairs and a worker receiving lacerations to his chest due to improper use of a mini-grinder. Applying a similar calculation as used for the 2009 shutdown, estimated work hours was 30,020 and incident frequency was 13.2. This was a significant improvement from 2009 shutdown results; however, these results did not meet the company expectations for safety in the workplace. Comparative smelter results for 2007 and 2010 were 2.5 and 3.0 respectively.

The above statistics for the 2010 shutdown do not include a very serious high potential incident in which a piece of roaster scale fell from the upper section of the roaster and hit the side of a worker. Fortunately, the worker was able to return to work after several hours in the hospital for medical observations. This incident occurred because the work plan did not include installing a safety net in the roaster to protect workers from this type of event. A long-standing standard operating procedure (SOP) has identified this requirement; however, the HRA for this job did not identify the requirement to install a safety net. Participants in the HRA process included appropriate subject matter experts including the area safety officer and experienced operating personnel. Prior to this event, experienced plant personnel and safety officers walked by and did not raise any concerns regarding failure to follow the plant SOP. The job owner was inexperienced in this role, but adequately trained. The root cause appears to be a lack of effective leadership by the area safety officer and experienced plant personnel.

Schedule management for roaster shutdowns is not effective. The October 2009 shutdown duration was two days longer than plan because of several deficiencies in project execution. The estimated lost production opportunity has an estimated value of $400,000. The shutdown did not have a strong daily focus on working to the defined schedule. It is essential that the shutdown manager set the tone to ensure all job owners are aware of this responsibility. This did not occur because of inexperience and lack of necessary training.

The October 2010 shutdown duration was five days longer than plan due to time required to complete necessary work in the roaster Venturi tower. Certainly, the condition of this vessel was poorer than expected and it was necessary to increase scope of work. The job owner managed the scope change well. He identified the potential problem to senior management who approved the increase in scope of work. Management then assigned additional people to manage this job to minimize schedule impact. However, process equipment condition does not fully explain the cause of the five-day extension.

The Venturi repair job started poorly. Detailed plans identified the need to install non-standard scaffolding due to the geometry of this vessel and specific job requirements. This information was contained in the job specific work package issued to the job owner and to the contractor. In spite of this information, the contractor, with acceptance of the job owner, chose to install standard scaffolding. Once installed, the contractors found that standard scaffolding was not satisfactory, and it was necessary to take this down and replace it according to the original plan. Additionally, the contractor brought in a crane with a boom of insufficient length at the start of the shutdown, and needed to replace it with a suitable crane. The job owner did not discuss crane details with the contractor prior to the shutdown based on an understanding that the contractor was well familiar with the worksite. These two deficiencies resulted in putting the project two days behind schedule at the start of the schedule. The lost opportunity due to extending the roaster shutdown in 2010 was $1,000,000 of which $400,000 can be attributed to shutdown management deficiencies. These deficiencies were a result of an inexperienced job owner not understanding the work plan and failing to ensure that the contractors performed the job according to plan.

Cost management for roaster shutdowns is not effective. Many of the tools are in place including: a daily recorded count of contractor workers on-site, the requirement for contractors to submit labour tracking sheets on a daily basis to Teck, job owner approval of tracking sheets, and a cost centre for collecting and compiling all information. The cost centre provides daily summaries to the shutdown job owners and the shutdown project manager. Smelter shutdown experience highlights the potential strength of this system. During the course of the smelter shutdown, job owners review all information and provide daily updates on cost to date and final estimated cost for each project. The shutdown project manager compiles all project cost information and reviews overall trends and projections. On conclusion of the 2010 smelter shutdown, the project manager identified total shutdown cost within $200,000 of the final cost of $37.3 million and he was fully aware of all areas of potential exposure.

At the roasters, the 2010 Venturi tower repair extended well beyond the original planned schedule. Plant management assigned additional resources to manage this job to minimize the schedule impact; however, neither the job owner nor the shutdown project manager identified the cost overrun for this job. The original budget for Venturi repairs plus hot precipitator was $1,350,000. Pre-shutdown, the finance group defined separate budget codes for the two jobs, but the job owner did not ensure proper separation of costs. Based on records maintained by the cost centre, a cost increase of $292,000 for these two jobs was booked at the end of 2010. Subsequent to this, in March 2011, the shutdown project manager identified an additional cost increase of $314,000 for these two jobs. Personnel involved attributed this problem to late submission of tracking sheets by the contractor. Neither the job owner, nor the shutdown project manager had performed any cross checking of daily worker count against tracking sheets. While certainly the largest discrepancy, other projects also demonstrated similar lack of job cost management. The root cause of this problem is lack of cost management by shutdown management team. The shutdown management team has not received necessary training in cost management.

The roaster shutdown team does not have an effective means for learning from its experience. Occasionally individual roaster job owners will complete a post mortem of their specific jobs; however, this is rare. The roaster shutdown manager leads a high-level shutdown post mortem meeting with shutdown job owners and support staff. He then prepares a post mortem document based on their input. This post mortem is very superficial and does not identify root cause of identified items, nor identify any responsibilities for follow up.

When major problems occur in a shutdown such as the poor safety results for the 2009 shutdown, the roaster operating manager will initiate separate actions to prevent reoccurrence. To determine how to improve safety performance, he met with the projects manager to determine necessary changes to the roaster shutdown process. This resulted in revising the shutdown organizational structure to create specific accountability for job owners to manage contractor work practices to the pre-defined safe work plans. This change contributed to the improved safety results achieved in 2010; however, the roaster shutdown team continues to have difficulty managing shutdowns to defined expectations. This problem is a result of an inexperienced team that does not have the necessary skills and training.

2.4.2 Roaster Front-End Engineering and Planning Capacity

Roaster front-end engineering and planning activities for major shutdowns do not deliver value for Trail Operations. Furthermore, the plant has difficulty in managing process equipment condition. The front-end engineers complete their activities in a hasty manner, resulting in late material deliveries and additional costs for specialized transportation arrangements. This section highlights several examples demonstrating a lack of effective front-end engineering and planning capacity at the roasters. This is due to a lack of technical depth in the business area and the lack of an effective process to build depth. The roaster organization is highly dependent on one experienced engineer who regularly assists with plant emergencies and problems in other departments.

Effective shutdown scope identification starts with a strong understanding of condition of plant process equipment. Equipment monitoring on an ongoing basis ensures a clear understanding of current equipment condition, and helps to develop an understanding of the link between process operating parameters and equipment condition. This focused approach ensures reliable operation of process equipment during the operating campaign, as well as a clear understanding of required inspection and repair activities for future shutdowns. The current structure for the front-end engineers does not promote a focused approach to front end engineering.

Unexpected equipment failures demonstrate deficiency in understanding process equipment condition. In November 2006, one of the cooling towers in the gas cleaning circuit had an unexpected packing collapse. To minimize the production interruption and manage within the available budget, a temporary $450,000 short-term repair was completed. The short-term fix has failed in 2009 and a $2,000,000 repair is required to ensure satisfactory operation for the long term. The unexpected failure was due to a lack of focus on equipment condition.

Deterioration of the Venturi towers was first identified in 2008 when process solution began to leak from the towers creating gassy conditions in the plant due fuming of sulphur dioxide from this process solution. Routine equipment inspections may have identified this problem earlier; however, a focused approach to managing process equipment condition could have prevented this problem.

The root cause of the Venturi tower leaks was failure of the silica brick lining in this vessel due to fluoride attack. Fluoride concentration in the circulating solution increased because of the need to treat a recycle material elevated in fluorine. Some time earlier, the plant eliminated routine chemical analysis of the circulating solution as a cost saving measure. When it was necessary to begin processing the recycle material there was inadequate consideration of potential impacts on process equipment. Once this situation was recognized, one of the plant engineers initiated a weekly chemical analysis of this solution for halides at an annual cost of less than $2,000. Operating procedures are in place to adjust the bleed stream from this circuit when necessary to control fluoride impurity. Total expenditure for repairing the two towers affected is in excess of $1,500,000. The root cause of fluoride damage to the towers is a combination of ineffective change control protocols and a lack of focus on equipment condition.

Unfortunately, there is a limited availability of experienced personnel in the business area. Many engineers are rotating through the plant to meet training requirements for new graduates. As a result, the business area has become highly dependent on the knowledge of one experienced engineer and the operating manager who plans to retire soon. This situation exposes the business area to increased risk of equipment failures in the future due to lack of experience. This situation has come about due to a strong focus on achieving short-term business results and an inadequate focus on long-term management team strength for the business area. Change is required to ensure effective knowledge transfer to the future leaders and support staff for this business unit.

Front-end engineers develop shutdown scope as part of the budget preparation process. Shutdown scope is highly dependent on inspection results of previous shutdowns. During a shutdown, plant engineers perform numerous shutdown inspections, and record equipment condition in a shutdown photographic library. However, there is no formal analysis or review of the importance of this information. Recently one of the engineers began to issue high-level inspection reports. This initiative should help in planning future shutdowns, provided this practice does not stop.

With planning tied to the budget process and corporate endorsement of the budget occurring very late in the year, front-end engineers rush project planning, resulting in performance gaps. For example in 2008, the plant procured a fibreglass reinforced plastic component from a shop in Ontario. Due to late and ineffective communications with the supplier, manufacturing of this $30,000 component was late. To meet shutdown timelines, purchasing arranged for team drivers to truck this component across Canada at an additional cost of $8,000. This component arrived one day late because of road restrictions and so installation did not occur. Alternate field repairs were completed and this component remains in storage. This problem is a result of high dependence of the business area on a few individuals and lack of effective coordination with the purchasing group.

This mode of rushed planning has become normal practice. In 2010, Trail Operations had a site-wide project to implement changes to reduce the risk of environmental spills to the river. This project required replacement of several oil coolers to mainline equipment at the roasters. This work could only be completed during shutdowns, and thus more than one order of coolers was brought in on a rush basis at an estimated cost of $20,000. This problem identifies a lack of effective coordination with the purchasing group.

Scope documents are often lacking in required detail for effective job planning. This is especially the case for the experienced engineer who completes front-end engineering for many of the more specialized projects and thus does not take the time to include the necessary level of detail in these documents. This requires the job owners to return to the experienced engineer for further definition of these details. Job owners also typically involve this engineer in the preparation of safe work plans due. The roaster organization lacks sufficient technical depth to perform effective front-end engineering and planning activities.

2.4.3 Safety and Health Management

Trail Operations does not have the capacity to support health and safety management of major shutdowns to expected standards. Previous sections have identified problems in completing work safely due to inadequacies in shutdown management. This section identifies difficulties in developing safe work plans in a timely manner because of a lack of available personnel with strong environmental, health and safety (EH&S) skills for shutdown management. Additionally there is a need to develop effective protocols for employees working with mercury-contaminated equipment.

Shutdown projects require contractors to prepare safe work plans before beginning work. This is not only good practice, but is a mandatory WorkSafeBC requirement. Development of safe work plans for shutdowns at Trail Operations requires the combined input of several subject matter experts including plant representatives to define specific scope of work and known hazards, contractors who provide specific trades knowledge, and EH&S experts familiar with regulatory requirements. The EH&S department was not able to provide timely assistance for the 2010 smelter shutdown. Due to lack of available expert resources, the smelter shutdown manager assisted the job owners whenever possible.

When it became evident that the EH&S organization could not provide the necessary support for the smelter shutdown, Ed Kniel, a former Trail employee was seconded from Teck's CESL group in Vancouver in June 2010 to provide the necessary assistance and leadership. Again, due to lack of available resources, the opportunity to develop a potential successor for this position was lost. The root cause was a failure to recognize the nature and importance of this role at Trail Operations.

With Ed Kniel on site, critical EH&S issues were addressed allowing safe work plans to progress; however, hygiene reviews became the next bottleneck. The requirement for hygiene permits is a recent development, and communication to the shutdown management team was ineffective. This review requires hygiene technicians to assess recommended personal protective equipment (PPE) for specific tasks against personal hygiene sampling data. A shortage of hygiene resources delayed these reviews, with the last one completed in September 2010 (Marsh, 2011: 13) one month before the shutdown. Contractors rely on a fully completed HRA to prepare the safe work plan for their workers. Many contractors wait until they received verification that they have a fully complete HRA before starting to prepare their safe work plans. As a result, many contractor safe work plans were prepared in a hasty manner. For example, WKM their safe work plan a few days before the smelter feed off. The root cause of the delay in completing hygiene reviews for shutdown HRAs is ineffective communication between the EH&S group and the shutdown management teams.

In March 2011, the roaster shutdown team has experienced similar delays in preparing for the April 2011 major shutdown of #10 Roaster. Four weeks before the shutdown, all aspects of the HRAs are complete, except for the hygiene reviews. This is the first time that hygiene permits have been required for roaster shutdown work. The hygiene department informed the job owners for the roaster shutdown of the requirement for hygiene permits less than two months before the start of this shutdown. This experience reinforces the need for better EH&S communication with the shutdown management teams.

Mercury handling concerns have recently become a high focus concern item. Because of this concern, a group began to develop protocols for handling mercury at Trail in a satisfactory manner to protect workers. Unfortunately, the group issued this document on September 27, 2010 a few days before the start of the smelter shutdown, and much too late to be included in the control plans for smelter activities. From a shutdown management perspective, the root cause of this problem is a lack of understanding by EH&S personnel of the impact of changes in safe work protocols to shutdown planning activities.

The roaster organization had a similar experience in 2008 with a very late change in safety standards for isolating confined spaces. The lockout team for the roaster shutdown decided to revise all applicable procedures in the weeks prior to start of the shutdown. This resulted in significant confusion to the shutdown management team. In many cases, job owners were not aware of the full extent of revisions made creating delays to the start of several jobs. It is critical that the issuance of revised safety and health protocols recognize potential impact on shutdowns. Failure to follow the new protocols can create political difficulties, while following them without adequate time to prepare creates worksite confusion.

The plants have recently experience a significant increase in the number of jobs requiring procedures to protect workers from the risk of mercury exposure. Early in the 2010 smelter shutdown, a discrepancy in the method used by the hygiene department to test for elemental mercury vapour was discovered. The extent to which this problem has affected previous mercury vapour measurements in roaster shutdown and routine maintenance activities is not known. This problem identifies a lack of technical depth within the EH&S group.

The 2010 roaster shutdown included repairs to the mercury removal tower. Routine blood sampling of workers during the course of the work identified a concern with some results exceeding 15 µg/L. When this problem arose, Teck stopped this job for 81 hours to perform a detailed review of all procedures associated with this job. The review identified a potential exposure to workers while removing contaminated gloves. The safe work procedures were changed, communicated to all workers, and then work restarted. The roaster organization managed this difficult situation very well. This experience highlights the importance of walking through safe work plans before beginning work to ensure control measures are effective.

Overall, there is poor level of understanding amoungst much of the workforce regarding the various chemical forms of mercury and the relative hazard of each. (Kniel, 2010: 36) Events such as the mercury tower experience create significant concern in the workplace. A portable Jerome meter is now readily available to measure atmospheric mercury vapour. Personnel with an inadequate understanding of the limitations of this instrument, and how to interpret results have used it in the workplace. Poor quality information developed in this manner has created a high degree of anxiety within the workforce. The root cause is a lack of controls or protocols for introducing new safety equipment within the workplace.

Another challenge related to mercury management is the cleaning of the powered air purifying respirators (PAPRs). Due lack of a demonstrated cost effective cleaning method 500 units used in mercury atmospheres have been bagged and placed in storage bins (Marsh, 2011). With a cost of $600 per unit, a cost effective means of cleaning will realize a saving of $300,000 by avoiding the need to replace these units. Existing staff require the assistance of expert technical help to overcome this problem.

2.4.4 Shutdown Waste Management

Trail Operations has designed its process operations to avoid producing process wastes and is currently working to treat accumulated process materials. Similarly, Trail Operations now has a project team working on water management to determine options for future operation with minimum or zero discharge of water effluent to the Columbia River. Waste material management has not received the same high focus at Trail Operations and this is resulting in stocking of shutdown waste materials that are not easily disposed of. This section describes various problems in managing shutdown wastes because defined responsibility for this issue is lacking.

Until recently, the scope of front-end engineering activity was limited to developing plans and cost estimates for developing solutions to specific problems. Waste disposal issues were not included in the scope of many projects. A common understanding was that waste materials could be set aside and eventually treated by the plants. Clear responsibility for managing the more troublesome waste materials is not evident. Where options exist, standards for delivery of waste are not clearly defined, or adhered to. Teck has individuals responsible for specific aspects of material waste management, but there is not a coherent process in place. The root cause is a lack of clear responsibility for this problem.

Currently waste materials disposal options include treatment in existing process plants, surplus sales, on-site landfill for clean wastes, and off-site landfill for contaminated materials.

Cleanliness standards for surplus sales and on-site landfill are well established and adhered to. This demonstrates that Trail Operations can effectively manage waste materials provided that clear definition of requirements and management responsibilities are in place and are well communicated.

The #2 slag-fuming furnace is a common destination for light burnable materials such as bag house bags, and waste one tonne bulk bags. This method of treating these waste materials results in an annual cost savings in excess of $200,000. The plant has defined acceptable standards for acceptable waste materials working with the environment group. Standards ensure the safety of furnace workers, prevent environmental harm, and prevent process problems such as furnace jacket failures or explosions. Past difficulties include an event in which the furnace discharged a large cloud of smoke. This event was clearly visible in downtown Trail and appeared on the front page of the Trail Times the next day. Consistent adherence to standards is essential to ensure that Trail Operations does not lose its social licence to treat these waste materials in a cost effective and socially responsible manner.

The smelter organization has defined very clear standards and approval procedures for treating waste materials in the #2 furnace. Waste materials must be dry and free of mercury or substances that may produce dioxins on combustion. The waste generator must fully fill and stuff waste materials into an appropriate bag. The process engineer for this area reviews all waste material treatment requests. During the 2010 smelter shutdown, routine audits identified inappropriate materials contained in bags directed for treatment in this furnace. This problem was caused by a lack of effective controls with unattended bags left open during stuffing. Workers walking by simply dropped unauthorized materials in these bags. Changes are required to ensure that this option for waste treatment remains a viable option for Trail Operations. The root cause is a lack of focus on adhering to defined waste disposal standards.

Mercury contaminated waste materials are a particularly challenging concern. Currently Trail Operations has two processing options. Lightweight materials such as plastic tower packing material can be disposed of in one of the zinc roasters. The generator of the waste must bag this material. The roasters are now processing a significant backlog of this material. In 2010, the smelter defined a method for processing lead metal contaminated by mercury. There is significant backlog of this material this material and treatment is very slow. In all cases, treatment requires plant operators to manually handle packaged waste materials and feed them into the roaster or furnace. Management focus is required to ensure regular processing of these materials.

Until recently, the next option for disposal of mercury-contaminated wastes from Trail Operations was to ship this material to the Clean Harbours landfill facility near Sarnia Ontario. Following completion of the 2010 roaster and smelter shutdowns, the shutdown managers were informed that Clean Harbours has a maximum mercury specification 500 ppm for incoming materials. As a result, the smelter and the roaster teams inventoried their waste materials post-shutdown. The smelter was fortunate in that shutdown wastes contained acceptable levels of contamination. The roasters were not as fortunate and will need to repackage materials from bulk storage containers. Plant engineers estimate that repackaging will cost in the order of $300,000. More significantly, there is not a defined destination for heavier mercury contaminated materials such as tower packing support beams and grating. The root cause of this problem is a lack of clear site responsibility for this problem. Because of this situation, front-end engineer and job owners develop disposal plans in isolation, and on a best efforts basis.

Previous KIVCET shutdowns have resulted in producing thallium contaminated waste materials such as scaffolding. The disposal route for this material was treatment in #2 slag fuming furnace. This disposal option disappeared when it was linked to premature failure of furnace sole jackets. Changed methods for cleaning the KIVCET boiler has eliminated the problem of thallium contaminated scaffolding; however, the smelter replaced a KIVCET boiler tube bundle in 2005. Without an identified destination for the old tube bundle, it was placed at a location formerly used as a temporary storage location for zinc concentrates. This has slightly reduced flexibility in zinc concentrate handling at Trail. More importantly, there is not a permanent destination for thallium-contaminated materials such as the boiler tube bundle. The root cause is a lack of defined responsibility for managing waste materials.

In the sulphuric acid plants service crew personnel clean the bottom of gas-gas heat exchangers and “knock out” vessels by shovelling the iron sulphate sludge into barrels. This material contains both mercury and nitrous oxide impurities. In this case, the nitrous oxide impurity is the major concern, as contact with waster will release a brown cloud of nitrous oxide gas from the sludge. In 1998, the plant installed a primitive means of processing this material in a ventilated tent. This treatment method stopped about five years ago because of worker safety concerns. Well over one hundred sealed barrels of this material is stored outside of the acid plants, and production of this contaminated iron sulphate sludge continues. A satisfactory method of processing this material is clearly required. The root cause of this problem is a lack of defined responsibility.

2.4.5 Additional Issues

Shutdown personnel have identified several additional challenges. Most important of these is the inadequacy of existing infrastructure. A review of the cost overrun for the Venturi repair job identified an unexpected cost of $120,000 in labour and overhead costs for transporting workers between the Warfield change rooms and the worksite at the roasters because of a shortage of nearby change room facilities. Similarly, deficiencies in the contractor lunchroom at the smelter required contractors to remove coveralls in a separate area before walking to the lunchroom. With two scheduled breaks every day, this easily added 30 minutes of non-productive time each day for all contract workers. Total cost for this one deficiency is $1.4 million. This issue has not received adequate attention due to lack of a focused resource to develop a solution. Plans are in progress to begin installing a new furnace in the smelter area. Now may well be the right time to invest in additional infrastructure.

Previous post mortems have identified the need to develop succession plans for the smelter shutdown manager. The 2010 smelter shutdown was an ideal opportunity to provide exposure and training to potential candidates. Trail Operations did not achieve any progress towards this objective in 2010 and there is currently no succession plan for this important role. The root cause of this problem is a lack of identified responsibility for filling this position.

3: Recommendations

This chapter presents recommendations to address the issues identified in shutdown execution and management. These recommendations build on identified gaps in shutdown management and demonstrated success in improving shutdown performance at the smelter. I recommend that fulltime shutdown project manager and shutdown EH&S manager positions be established for Trail Operations to achieve best practice in the management of major shutdowns. In addition, I recommend that the roaster business area establish process equipment integrity teams to increase its focus on process equipment condition and to effectively transfer technical knowledge to the next generation of engineers. A shutdown management steering committee is required to oversee the shutdown management process and to implement necessary change initiatives to deliver the required improvement in shutdown management performance.

3.1 Full Time Shutdown Manager

Specialized project management skills are required to achieve effective shutdown management for the major shutdowns. A shutdown manager must have effective planning skills, strong communication skills, attention to detail in a very dynamic environment, and the ability to hold the shutdown management team accountable for its performance. Discussions with smelter personnel at five other smelters including Canadian, American, and Australian operations indicate that the Trail lead smelter exhibits an uncommon best practice, or near best practice, on all critical areas of shutdown management. A very common understanding of shutdown management is that shutdown scope is loosely defined and many changes occur as inspections are made (InterPlan, 2005). The smelter shutdown team has demonstrated that this need not be the reality of shutdown management at Trail and the smelter shutdown manager has had an important leadership role in changing this reality. I recommend that the incumbent smelter shutdown manager be recognized and assigned to a fulltime role of shutdown manager. This change will enable other business areas at Trail to benefit from his shutdown management skills and knowledge.

The smelter team has demonstrated the ability to manage shutdowns as projects with the added challenges of protecting workers from significant process material and physical hazards, extensive permitting requirements, compressed timelines, and the ability to effective work with the results of equipment inspections. This team has effectively integrated many of the Trail support functions into the shutdown process. It has carefully managed scope, completed shutdowns on schedule, and managed costs to budget. The team has established effective quality management, developed personnel for shutdown roles in a timely manner, and established effective communication protocols. It has effectively managed project risks, and has achieved significant improvement in procurement activities. This team manages all of the eleven generally accepted project knowledge areas (Project Management Institute, 1996) to a high standard. Comprehensive job specific and shutdown organization post mortems are now completed, and follow up plans are developed. Many of the deficiencies identified in 2005 have been resolved. The 2010 shutdown post mortem has identified additional deficiencies to resolve and the core smelter-shutdown management team is working on a path of continuous improvement to achieve best shutdown management practice.

Recognizing that the smelter shutdown management-team has evolved and has developed essential and unique skills to ensure effective management of shutdowns it is clear that other business areas at Trail are likely to benefit. The roaster business area has a strong need to improve its management of major shutdowns. From 2009 to 2010, the roasters experienced an improvement in safety performance by changing the shutdown organizational structure to align with the structure used to manage major shutdowns at the smelter. The 2010 experience demonstrates the need for a significant improvement from this result. This is most easily achieved by working with well qualified on-site experts in shutdown management.

The smelter business area has identified an opportunity to improve shutdown management effectiveness of their minor and opportunity shutdowns by applying common practices used to manage major smelter shutdowns such as scheduling and completing post mortems. Similarly, the zinc-leaching business area has identified the need to improve several aspects of shutdown management. Plant personnel have identified the need for improved interplant communication and scheduling. Implementation of post mortems with identified root causes of problems will ensure additional benefits.

Furthermore, the existing smelter-shutdown management team is not fully occupied in planning and managing shutdowns. Currently the smelter shutdown manager only works in this capacity when required to plan and execute major smelter shutdowns. Outside of these times, he oversees implementation of the portfolio of minor and major projects in the lead smelter and refineries. I recommend that the smelter shutdown manager will deliver greater value to Trail Operations by assisting other business area to in establishing improved shutdown practices. To make this happen would require hiring an additional project group superintendent. The annual cost for this position is less than $200,000 per year. The following sections describe the recommended responsibilities for the full time shutdown manager. The first three sections address specific problems identified earlier, and the next two identify additional opportunities to deliver value for Trail Operations.

3.1.1 Lead Smelter Shutdown Manager

This responsibility includes all activities required to effectively prepare for and lead the execution and coordination of smelter shutdowns. This includes ensuring all projects have a defined written scope, and are executed to meet the safety, environmental, cost and schedule objectives set by Teck management. The KIVCET 2010 Shutdown Roles and Responsibility document effectively describes the specific responsibilities of this position.

To ensure smelter shutdowns continue to meet expected performance levels requires full time commitment by the smelter shutdown manager to this role for six to seven months for every major shutdown. This includes four months of detailed planning prior to the shutdown, one month to manage the shutdown and a minimum of one month for follow up. The incumbent shutdown manager will continue to lead in this position until he has developed a successor.

In addition to this full time commitment, the shutdown manager requires 10-20% of his time to prepare for the next smelter shutdown. Activities include familiarization with specific shutdown projects, ensuring front-end engineering activities stay on schedule, and initiating coordinating activities with other groups. This is an ongoing responsibility for the incumbent based on the effectiveness of past practice.

3.1.2 Management of Major Roaster Shutdowns

The shutdown manager has two options for managing major roaster shutdowns. One is to take on this responsibility and the second is provide oversight, guidance and mentoring to the senior shutdown coordinator for the roasters. The first option is a suitable option for the short term; however, if the shutdown manager begins with this approach he must evolve his role to the second approach to meet the long-term needs for shutdown management at Trail Operations.

Taking on the role of roaster shutdown manger will ensure a rapid improvement in roaster shutdown performance. Job owners will fully become aware of their responsibilities and learn the necessary skills to safety manage projects, without environmental harm, on time and on budget by ensuring contractors work to predefined plans. Job owners will communicate problems in a timely manner during the course of the shutdown. The shutdown manager will become familiar with the unique aspects of roaster operation such as the need to complete work while parallel process is in operation. Unfortunately, this approach will result in the incumbent smelter shutdown manager becoming invaluable for another critical position at Trail Operations. A second equally important problem is the occasional requirement for overlapping roaster and smelter shutdowns.

I recommend that the position of roaster shutdown manager become an opportunity to train the successor for the current smelter shutdown manager. The roaster business area regularly experiences the second largest shutdown event at Trail. These shutdowns are significant in capital expenditure, and have similar process, safety and environmental challenges as experienced at the smelter. The roasters have one major shutdown every year, and thus there are many more opportunities to become a proficient shutdown manager at the roasters than is possible at the smelter.

The major shutdown manager should provide technical oversight of the roaster shutdown manager. The major shutdown manager will need to frame recommended responsibilities and timelines for roaster shutdowns that will require the endorsement of the roaster operating manager. On his endorsement, the major shutdown manager can provide necessary technical leadership and guidance to ensure that the roaster shutdown manager performs her/his responsibilities in a timely and effective manner. When the roaster shutdown manager faces obstacles that the operating manger cannot address, the major shutdown manager will be able to provide additional support and options for consideration.

The major shutdown manager will have full technical responsibilities for the roaster shutdown manager including recommendation of essential training. The major shutdown manager will evaluate the roaster shutdown manager to determine suitability for the role of smelter shutdown manager. Recognizing that the incumbent smelter shutdown manger will likely retire after two more smelter shutdowns, development of the roaster shutdown manager is time critical if this position is to be used to develop the successor for the smelter shutdown manager. It may be necessary to put other individuals in the role of roaster shutdown manger if the incumbent does not develop as quickly as necessary.

The shutdown manager will add technical depth to the existing shutdown management team by ensuring all essential planning and team training occurs. He will define shutdown team roles and responsibilities with input from the roaster operating manger. He will guide the roaster shutdown manger to ensure all individuals understand their roles and are trained to effectively perform their duties, and are accountable for performing to the defined expectations. He will also have the opportunity to identify critical gaps in real time and develop plants to address them. This change will build capacity of the roaster shutdown team to manage shutdowns to the expected standards for Trail Operations.

3.1.3 Improve Shutdown Performance at Trail

An important role for the shutdown manager is to improve shutdown performance at Trail. Currently smelter shutdowns suffer from deficiencies in a number of areas such as contractor capacity to develop safe and efficient work plans, and due to low worker productivity resulting from deficiencies in the Trail infrastructure. The incumbent is well familiar with the specific details of these issues and I recommend that he identify options for addressing these issues.

In the areas of contractor capacity, it may require working with existing contractors to increase their capacity, and/or to consider evaluating other contractors for performing these jobs. Similarly, an engineering company would likely develop the specific plans for improving site infrastructure, but the shutdown manager would be able to define specific requirements to the engineer and identify specific benefits to the senior management group that must approve these expenditures. This responsibility ensures continuous improvement of smelter shutdowns, and provides opportunities to achieve gains for other business areas.

3.1.4 Minor and Opportunity Shutdowns

Several business areas at Trail Operations have identified opportunities to improve shutdown management. Many of the specific issues are similar to those experienced in managing major shutdowns. I believe this is an opportunity for the incumbent to leverage his knowledge of existing skills and systems to assist with these issues. This section reviews specific opportunities for to improve performance of smelter minor shutdowns and zinc leaching plant opportunity shutdowns.

The lead smelter has identified an opportunity improve management of minor and opportunity shutdowns. Minor shutdowns have many of the same challenges as the major shutdowns including EH&S management, scheduling, cost management, and communications. Quality post mortems and follow up are essential to achieving performance improvement. The smelter shutdown manager is well familiar with the smelter site. Discussions between the shutdown manager and the operating manager will define the required skill development for the smelter senior shutdown coordinator. Capturing small gains by reducing the length of smelter shutdowns will achieve significant production benefits through the year with eight opportunity shutdowns and one minor shutdown in the smelter every year. The operating manager has identified the need for post mortems for these shutdowns. Guidance and training by the major shutdown manager will ensure useful post mortems are prepared. The major shutdown manager will also be a useful mentor in developing follow up strategies. This role will also expose the shutdown manager to other potential candidates for succession planning purposes.

The zinc leaching plant has identified the need to improve shutdown performance. Critical aspects are effective coordination with the cell cleaning activities in the electrolytic plant, and improving plant start up protocols. The major shutdown manager could provide technical assistance to the plant by reviewing scheduling practices and communication strategies; however, more importantly is to establish the process of continuous improvement by routinely completing a post mortem following each shutdown and then establishing follow up strategies. The practice of post mortems is not common in the leaching business area. The major shutdown project manager will need to develop a strategy to provide needed training and mentoring.

3.1.5 Mentoring Plant Shutdown Coordinators

The shutdown manager will establish a working team of plant shutdown coordinators to review plant post mortem suggestions and develop common approaches to solving problems. He will identify common difficulties and prepare training and other strategies to overcome these difficulties. The manager will be available as an expert resource to provide guidance for the plant coordinators. The shutdown manager will be able to leverage on established shutdown procedures and training to achieve benefits for other business areas.

3.2 Shutdown Environment, Health and Safety Management

The 2010 smelter shutdown experience demonstrated the need for a smelter shutdown EH&S manager. I recommend that Trail Operation hire a well-qualified individual for in the fulltime position of shutdown EH&S manager. He/she will provide specific expertise to ensure Trail’s environmental, health and safety systems fully support shutdown requirements. The annual salary cost for this position will be less than $200,000.

The shutdown EH&S manager will report to the Trail Manager, EH&S but routinely work with the shutdown project manager. During shutdowns, she/he will functionally report to the shutdown project manager and will oversee site safety coordinators, environmental engineers, and technicians. This individual must be capable of working in a very dynamic and changing environment to meet shutdown needs. This individual must also be effective between shutdowns while working in an EH&S support role.

This individual will be responsible to manage EH&S shutdown planning activities, manage the shutdown EH&S function, improve the EH&S process for shutdowns, and establish site protocols for shutdown waste management. The person selected must be well experienced in managing environmental and safety responsibilities within an industrial metallurgical complex. The following sections describe the recommend responsibilities for the shutdown EH&S manager.

3.2.1 EH&S Shutdown Preparation

The shutdown EH&S manager is responsible to ensure effective input to the shutdown planning process to ensure that work can be completed without harm to workers or the environment. He/she will become familiar with all planned jobs and consider both job specific and macro jobsite issues. The incumbent will also define EH&S support requirements for the shutdown.

The incumbent will become familiar with specific shutdown projects in the year leading up to the shutdown and assist the job owners in developing safe work plans. This individual will ensure that these plans not only address the specific environmental, health and safety aspects of the specific job, but also recognize the potential for overlapping hazards with other jobs on site. This person is responsible to ensure that the project adheres to and effectively implements Trail's environment, health and safety policies. She/he will identify potential macro issues that could affect shutdown execution and will recommend strategies to address these issues.

The shutdown EH&S manager will ensure the contribution of appropriate subject matter experts to assist the job owners in preparing safe work plans. The incumbent identifies opportunities to involve additional personnel in a controlled manner for development purposes. He/she will ensure that contractors are involved as early as possible in developing shutdown plans. Contractors will be encouraged to include their safety representatives into this process to ensure a good understanding of the safe work plans, and to understand local contractor capability so that there are no surprises during the shutdown. The shutdown EH&S manager assesses qualifications of each contractor's 'qualified person' prior to accepting these individuals on site.

A key deliverable is to define the EH&S expectations and expectations of all personnel working within the shutdown. She/he will recommend specific EH&S organizational roles within the overall shutdown management team to achieve expected environment, health and safety standards. The incumbent will work with support groups such as the medical, industrial hygiene, and analytical services groups to ensure adequate preparation for the demands of the upcoming shutdown(s). These responsibilities directly address the EH&S resource deficiencies identified for smelter shutdowns and will contribute to improved EH&S safety planning at the roasters.

3.2.2 EH&S Support for Shutdown Execution

During plant shutdowns, this individual has overall responsibility for coordinating environmental, health and safety activities on site. She/he maintains a visible presence on site and performs routine audits to confirm all employees on site work to the safe work plans. The shutdown EH&S manager ensures that all EH&S personnel provide effective and timely support for shutdown activities. Environmental, health and safety measures are tracked to ensure compliance to established measures, and performance to expected corporate and regulatory standards.

The shutdown EH&S manager promptly reports all incidents to the shutdown project manager. He/she ensures job owners investigate environmental, health and safety incidents in a timely manner with participation of appropriate subject matter experts. This individual is Teck's primary contact for all EH&S activities during the shutdown. She/he meets with Worksafe BC and Ministry of Environment officials when they come on site for any purpose.

The incumbent maintains a daily log of all EH&S activities, discussions and issues, as well as a log of issues for post mortems. Following the shutdown she/he leads a EH&S post mortem with input from all EH&S employees and issues it to the shutdown project manager and the Trail Manager, EH&S. The EH&S manager contributes to the overall smelter shutdown post mortem thereby supporting continuous improvement of EH&S activities.

This role is an essential role for the major smelter shutdowns as demonstrated in 2010. The establishment of fulltime shutdown EH&S manager for Trail ensures the availability of a qualified person for smelter shutdowns when needed. Working in this role during roaster shutdowns, when possible, will ensure strong EH&S support for the roaster team. This responsibility will contribute to improvements in safety performance for future shutdowns.

3.2.3 Improve EH&S Process for Shutdowns

An important task will be to review existing processes used to ensure that they deliver the required results in an efficient and timely manner. Current experience suggests that there are significant bottlenecks in this process due to resource constraints. The process should be reviewed to identify methods overcome these delays.

The incumbent will liaison with technology experts to find efficient ways for the hygiene technicians to work with safety and health data. The privacy act limits the information hygiene technicians can provide on individual exposures to specific jobs. A much less tedious process would benefit both the technicians and the shutdown job owners.

Workplace standards and demands change regularly in response to new information. The recent identification of potential mercury hazards in many more locations is a current example of why it is necessary to address these concerns in a timely and effective way. A shutdown EH&S manager can work with appropriate personnel within the EH&S group and the shutdown management teams to ensure any changes are rolled out in a way that does not impair shutdown efficiency or cause harm to workers or the environment.

This responsibility ensures that the EH&S function at Trail operates efficiently to meet shutdown planning requirements. Working with shutdown teams, the incumbent will be well aware of the specific requirements of this group. Similarly, the incumbent will also be aware of upcoming regulatory changes and can influence the roll out of changes to ensure effective field implementation,

3.2.4 Shutdown Waste Management

The shutdown EH&S manager will facilitate the process of improving shutdown waste management. The full process of shutdown waste management will be considered including, temporary storage, cleaning for final disposal, transportation, longer-term storage if required and final disposal. The incumbent ensures that appropriate technical standards, permit requirements, and cost information are prepared and are easily accessible by the front-end engineers and shutdown management teams to allow these individuals to develop effective plans.

The incumbent may sponsor, lead or participate in teams to address some of today's long-term waste challenges. Periodic auditing of these waste materials is also required. This responsibility ensures a single point responsibility of this problem. The incumbent will need to work with individuals in many departments to develop a comprehensive approach to managing this problem.

3.3 Process Equipment Integrity Teams for Roaster Operations

I recommend that the roaster business area form three integrity teams: one for the roasters, a second for the sulphur gas handling (SGH) plants and a third for the zinc pressure-leach plant. These teams will ensure effective knowledge transfer thereby increasing the number of knowledgeable individuals in the business area, reduce risk of process equipment failures, and ensure higher quality and improved timeliness of front-end engineering activities. This recommendation serves to build roaster front-end engineering and planning capacity. The next four sections describe the composition and various responsibilities of the integrity teams. The final section identifies an interim measure to improve front-end engineering for process areas without integrity teams.

3.3.1 Integrity Team Composition and Routine Responsibilities

An effective process-equipment integrity team requires input from various perspectives. Based on smelter experience, an ideal team includes participation from plant maintenance engineers, plant process engineers, operating management, area operators, plant technicians and available site subject matter experts. The team meets on a regular basis with frequency defined by the level of activity required for the process area. For example, the smelter-furnace integrity group meets monthly while the smelter-boiler integrity group meets quarterly. Based on this experience and current process equipment condition in the roaster business area I suggest that the SGH integrity team meet monthly and the other two teams quarterly. Further discussion of integrity teams will focus on the SGH team. This should be the first team established because of equipment condition and process needs.

The SGH team will have oversight of the wet electrostatic precipitators, the mercury removal plant, the three acid plants, and ammonia scrubbing. Prior to meetings assigned team members will compile status and performance of all major process units in these plants. The team will discuss this information, add any additional pertinent information, and follow up on previously identified action items. Members identify additional action items during the meeting and assign specific responsibilities and timelines. The team distributes minutes to all affected plant personnel. Feedback provides useful starting points to identify additional concerns, and to discuss the function of this team thus building credibility within the workplace. A team environment will foster the transfer of knowledge and skills from a small number of experienced personnel to a larger group of technical personnel in the business area as they discuss current issues and equipment problems.

3.3.2 Integrity Team Shutdown Responsibilities

During a shutdown, individual team members will have responsibility for quality assurance as previously defined for smelter shutdowns. This responsibility includes defined equipment inspections and inspections of contractor repair work to defined expectations. This responsibility will allow the roaster job owners and contractors to have a high focus on completing the work to shutdown plans.

Following the shutdown the team will review all results and recommend a path forward for future routine and shutdown repairs of the process units. Once the integrity team has identified shutdown scope, they meet with the operating manager to ensure a full understanding of critical activities and subsequently a summary document is prepared. Early shutdown scope identification directly addresses critical deficiencies in defining shutdown scope and completing front-end engineering activities at the roasters. Scope is determined on a common understanding of equipment deficiencies. Early scope identification provides the best opportunity to complete front-end engineering and planning activities in a timely manner.

3.3.3 Integrity Team Planning Responsibilities

The SGH integrity team will assign individual team members specific responsibilities to deliver scope definitions, budget estimates and safe work plans for each defined shutdown project. The assigned team members will work the site subject matter experts, engineers, job owners, and contractors as required to pre-defined deadlines.

Schedules for completing safe work plans will consider more than minimum deadline requirements. Smelter experience demonstrates that teams build credibility by working to more aggressive deadlines; ideally, the team should set deadlines by what is practical to achieve looking forward, rather than what is necessary to achieve by working backwards from budget and shutdown schedule dates. In this way, the team will be ready to provide necessary project information when opportunities arise.

Many of the defined projects are not new to the operation, but rather are modifications of shutdown projects completed in prior years and the team will draw on relevant documents from previous shutdowns. Over a period of years the integrity team will build a library of model job plans to simplify this process. This approach will directly address deficiencies in shutdown planning and also add planning capacity as model jobs are developed.

3.3.4 Integrity Team Objectives

The team will require specific equipment objectives to guide this process. Ideally, one would receive this information from the operating manger and the team would work to achieve these objectives. This did not occur in the smelter, and it is unlikely to occur in the roaster business area. The smelter objective for a four-year operating campaign for the KIVCET furnace came from one subject matter expert, and the team worked to define changes needed to achieve this result.

Similarly, the SGH team will need to consider potential objectives, and work in tandem with the operating manager to establish clear objectives. One advantage for the SGH integrity team is that many of the process units are not unique and the team can look to the experience of others. For example, Du Pont has several sulphuric acid plants at various locations across the United States. Their standard operating campaign between shutdowns is two years unless restricted by local state law. Canadian Electrolytic Zinc operates to an eighteen-month operating campaign between shutdowns for their roaster and acid plant operations. This and additional benchmarking information will guide the team and the operating manger in defining specific objectives for the SGH plants at Trail. Clear objectives will ensure a sound and consistent basis for defining shutdown scope.

3.3.5 Interim Recommendation for Improved Front-End Engineering

I have included this interim recommendation for improved front-end engineering based on the recognition that full implementation of integrity teams in the roaster business area will take some time to complete. It is important that the plant allot sufficient time to form strong teams rather than rapidly forming teams for all areas. Significant support is required to ensure an effective start for these teams. This section identifies an interim measure for defining shutdown scope as early as possible for process areas without an integrity team.

I recommend that the business area manager meet with plant maintenance engineers following the shutdown, and discuss inspection results and agree to the scope of work for the next shutdown. Preliminary schedules for front-end engineering activities can be defined as soon as this is completed, enabling a much earlier start to this activity. This approach avoids the need to rush through preparation of shutdown work packages. This interim recommendation serves to achieve an immediate improvement in shutdown planning by ensuring an earlier start to front-end engineering activities and planning.

3.4 Shutdown Management Steering Committee

The preceding recommendations cross business area boundaries at Trail Operations and require the support of additional functional groups at Trail. I recommend the formation of a steering committee to define a common vision and objectives for shutdown management at Trail Operations. This committee will define the overall strategy, and oversee implementation of these change initiatives and other projects designed to deliver the desired improvement in shutdown performance. This committee will provide the necessary focus on shutdown management and ensure assign accountabilities for implementing the necessary changes on a priority basis. The following sections describe committee composition and responsibilities.

3.4.1 Shutdown Management Steering Committee Composition

This steering committee should include managers of functional groups most affected by shutdown management at Trail. As a minimum, this committee should include managers of maintenance services, production, EH&S, and Trail projects. Regularly reporting to this committee will be the operating managers of affected plants, the major shutdown manager, and the shutdown EH&S manager. Others may report to the steering committee from time to time based on the status of specific improvement projects. This structure establishes the necessary accountability for operating and shutdown managers to deliver the required changes to the shutdown management process at Trail.

3.4.2 Shutdown Management Steering Committee Responsibilities

The steering committee will define the common vision and direction for shutdown management at Trail, recognizing different needs for the various plants at Trail, as well as the nature of each specific shutdown. This responsibility will require broad input from the various stakeholders affected. The steering committee will assess all proposed projects and implement approved projects to achieve improved performance on a priority basis. The committee will monitor progress to ensure achievement of identified goals. The committee also exists to remove obstacles experienced by those implementing the changes.

This paper presents more recommendations to improvement shutdown performance at Trail than can be achieved by creating two new positions and changing the focus of engineers in the roaster business area. Additional improvements require the steering committee to initiate specific projects with individuals working to solve defined problems and obstacles impairing shutdown performance. The committee will ensure business-area manager support for these projects before investing in the projects. With support of affected managers, the committee will provide the necessary resources to complete the necessary change initiatives.

4: Implementation

Achieving best major maintenance shutdown management practices at Trail Operations requires a defined implementation plan. Many organizations try to remake themselves, but only few succeed. John P. Kotter in his article “Leading Change: Why Transformation Efforts Fail” (Kotter, 2007) identifies a series of steps associated with successful transformation efforts. This chapter proposes an implementation plan based on these concepts.

4.1 A Case for Action

To make a change, a case for urgency is required. Over 50% of company transformation initiatives fail due to a lack of urgency (Kotter, 2007). The case for implementing changes to shutdown management at Trail Operations is significant.

Successful management of major shutdowns at Trail Operations is essential to the success of the business. Trail has experienced significant failures including the worker exposure to thallium during the 2001 smelter shutdown. This event raised major questions in regards to Trail’s ability to manage worker health, specifically the required shutdown activities in the smelter boiler. The work site was shutdown and a significant extension to the shutdown resulted while improved methods for worker protection were developed, and reviewed with all stakeholders. Because of this incident, Trail Operations has made significant improvements to risk management protocols.

In 2010, a significant challenge arose in regards to effective management of worker exposure to mercury. Fortunately, there was early identification of a potential problem, prompt action to improve decontamination procedures. Outstanding questions remain unanswered in regards to safe work procedures for working in mercury-contaminated environments. In 2013, the lead smelter is planning to perform major repairs to a vessel contaminated with mercury. Will there be sufficient focus on mercury management? Will the right information for working with mercury-contaminated materials be available, including procedures for dealing with waste materials?

Existing shutdown management practices lead to a lack of focus on building an infrastructure to maximize worker productivity during the shutdown. A full time focus on shutdown best practice will ensure shutdown infrastructure improvements are well defined. These improvements will achieve significant cost savings, and have the potential to reduce the duration of smelter shutdowns. The site facilities to clean powered air purifying respirators (PAPRs) demonstrate what Trail can do. A management person recognized the significant cost of replacing units that had not been properly stored between shutdowns. Hundred of PAPRs with a cost of $600 per unit were disposed as result of this problem. Trail has built a facility to clean and properly store these units. The supplier of these units considers this facility to be the world best practice. Significant cost savings are achieved every shutdown because of this facility. Many other opportunities are readily apparent, but require focus to deliver the benefits.

The roaster business area has experienced significant difficulties in shutdown management due to a lack of experience. This has resulted in poor safety performance, as well as difficulty managing shutdown work to budget cost and schedule. Changes are required at the roasters to ensure effective shutdown management.

The smelter shutdown manager has developed a high level of skill and knowledge in managing major shutdowns. The roaster business area would benefit from applying his talents to the major shutdowns at the roasters, and the lead smelter would benefit by learning from roaster shutdown experience. More importantly, Trail Operations needs to develop a successor for the smelter shutdown manager. Failure to do so will result in a significant loss of skills for Trail Operations and the lead-smelter business area when the incumbent retires. The incumbent has made a significant contribution to improving smelter shutdown performance. This individual has worked collaboratively with others to develop improved systems. Systems are slowly transferring into the roaster business area; however, his skills and knowledge have not been widely taught to others. Failure to transfer these skills to other business areas represents a significant lost opportunity.

4.2 Building a Coalition

"Major renewal programs often start with just one of two people. In cases of successful transformation efforts, the leadership coalition grows and grows over time. But whenever some minimum mass is not achieved early … not much happens" (Kotter, 2007: 98).

The present investigation into shutdown management practices and experience at Trail has included interviews and discussion with Manager, Maintenance Services; Projects Manager; Operating Manager, Roasting & Sulphur Products; Sr. Shutdown Coordinator, Roasting & Sulphur Products; Operating Manager, Lead Smelter Operations; Lead Smelter Shutdown Project

Manager. All of these individuals have identified the need to improve in our ability to manage shutdowns, and have significant interest in achieving improved results. The need for greater focus to achieve this improvement is recognized, and several individuals spoke to the need for a permanent team for shutdown management and for mentoring plant personnel managing smaller shutdowns.

The managers in this group are ideal candidates to build support for a defined approach to improve shutdown management at Trail. A common understanding of goals and a general path forward is the first step in this journey. Recruitment of additional team members to fill critical needs will follow. Involvement from the Environment, Health, Safety and Quality group is required. Additional support from the ranks of the senior management group would add credibility to the process. This group will provide guidance to the core and plant shutdown teams to ensure progress to defined goals. Once a shutdown management steering committee is formed this group can revert to its roles in that organization.

An ideal opportunity for this group to meet would be in May following the April/May 2011 major shutdown of #10 roaster. All of the major Trail shutdowns will have occurred in the preceding nine months, and the next major shutdown is planned to occur sixteen months later. This is clearly a time for reflection on results achieved, and an opportunity to build strength into major shutdown management practices. Prior to this shutdown, it would be worthwhile for the roaster shutdown team to receive training in preparing effective shutdown post mortems to maximize input into this process.

4.3 Creating a Vision

"In every successful transformation effort that I (Kotter) have seen, the guiding coalition develops a picture of the future that is relatively easy to communicate and appeals to customers, stockholders, and employees" (Kotter, 2007: 98). A current understanding of the vision for the group to work with is described below.

Today's view of management shutdown management considers this activity as a necessary, and expensive, cost of doing business. Let us turn that around and look at how we add value by effectively managing shutdowns, not only to prevent harm to individuals and the environment, but instead to add value to plant operations. *"Turnaround management"* likely provides a better descriptor of the desired result. The vision must consider improvements to plant operating performance including on-line time and/or operating rate, extending the duration of the operating campaign between shutdowns, as well as reducing costs and downtime required to complete the turnaround. The core shutdown team participates in working towards these goals by effective management of the shutdown planning, execution and follows up processes.

The plant business area participates in this process by setting appropriate and clear operating goals. This process has been particularly effective in the smelter where the furnace integrity group has set a goal of achieving a four year operating campaign between shutdowns. The roaster group needs to evaluate the potential opportunity to establish integrity teams to improve operating results and shutdown performance. The SGH plants represent an ideal area to implement this concept.

4.4 Communicating the Vision

Communicating a vision for the future is particularly challenging. … "Communication comes in both words and deeds, and the latter are often the most powerful form" (Kotter, 2007: 100).

The best approach to communicating the vision for improved shutdown management is to link actions with the vision. The Operating Manager, Lead Smelter Operations has a clear vision for improved shutdown management in his area. This individual transferred to the smelter area in 2010 a few months prior to the 2010 major shutdown. He recognized that there was not an overall post mortem completed following the 2007 shutdown. He initiated necessary activities to develop a pseudo post mortem for the 2007 shutdown and ensured implementation of necessary follow up actions. He provided necessary leadership to ensure completion of project specific and overall shutdown post mortems following the 2010 shutdown. He has strongly influenced activities necessary to have a defined strategy for follow-up.

Similarly, the roaster organization could establish an integrity group to monitor and manage process equipment condition. The SGH plants are an ideal place to begin this process. The 2009 condition based assessment of all major equipment in SGH is a useful starting point for future inspections and repairs. The acid plant renewal project will benefit from this approach, as the future commissioning teams define the path forward for managing equipment condition. It is essential to communicate this linkage to future shutdown practices.

The roaster and smelter shutdown teams need to establish a closer working relationship to enable cross learning to occur more quickly, and become an unofficial core shutdown team. This team should include the front-end engineers at the roasters and the smelter, shutdown coordinators of both areas, and the smelter shutdown manager. The proposed team will meet on a regular basis to share experiences from previous shutdowns, upcoming challenges and common issues. An important goal will be to establish a common approach to the shutdown planning and execution strategy would develop based on best practice arising from both areas. As the teams begin to closer working relationships, it could well be that the two teams become one team in practice.

4.5 Empowering Others to Act on the Vision

"To some degree, a guiding coalition empowers others to act simply by successfully communicating the new direction. But communication is never sufficient by itself. Renewal also requires the removal of obstacles" (Kotter, 2007: 101).

Current shutdown performance measures focus on the shutdown outcomes. Specific measures used include workplace safety results, environmental incidents, and completing the work on time and on budget. The shutdown management team, plant management and senior management review these measures but outside this group, this information is not known except in situations when a major problem arises.

It would be worthwhile to develop additional measures that relate to the effect individuals can have on a shutdown. For example, measures such as savings on procurement and contractor efficiency are measures that individuals can understand and find ways to achieve improved performance. Linking these measures to shutdown planning activities and to changes in use of infrastructure issues will provide regular opportunities to share the vision, and identify constraints or obstacles to improved performance.

It is important that there be routine discussions of these measures and the impact of individual action of group performance. Discussions should recognize contributions made to achieve improved performance. For example, improved integration of procurement in the shutdown planning process for the smelter has resulted in significant cost reductions. Sharing the impact of these changes will help others to determine additional approaches to improved performance.

4.6 Planning for and Creating Short Term Wins

"Real transformation takes time, and a renewal effort risks losing momentum if there are no short term goals to meet and celebrate" (Kotter, 2007: 102).

It is estimated by the author that total cost savings achieved in the last shutdown by effective integration of purchasing into the smelter shutdown planning process were in the range of $1-2 million, of a total $37.3 million expended. It is suggested that a simple method of estimating these savings during the next shutdown be devised, and the results widely communicated on *Tadanet.* Identification and recognition of this result, and the contributions made by the shutdown management team, front-end engineering staff and the purchasing will encourage others to follow suit. Similarly, identification and communication of the results achieved benefits achieved by the established integrity groups, and the recently implemented quality assurance protocols in the smelter are positive examples for other business areas to follow and achieve improved results.

4.7 Ongoing Steering Committee Responsibilities

The shutdown steering committee will be a key driver for future change. As improvement demonstrate clear benefits to the smelter and roaster business areas, these changes will need to be recognized and then consolidated and institutionalized throughout Trail Operations. It is essential to anchor new shutdown processes in the culture (Kotter, 2007) of Trail Operations. A critical risk for the steering committee to be aware of is to declare success too early (Kotter, 2007) and break up the steering committee.

5: Conclusion

Major maintenance shutdown management is an important contributor to success of Trail Operations. The site has achieved significant improvement in shutdown management over the past decade. Experience has demonstrated that any gap in shutdown management can be very costly in terms of worker life and quality of life, impact on our environment, production results from the operating plants, as well as the financial cost of the shutdown itself. Difficulties of the 2010 shutdowns demonstrate that we have not yet achieved the standard that we expect of ourselves.

Successful shutdown performance begins well before the actual shutdown event, and includes activities that continue well after the last contractor leaves the work site. There are four key components required to deliver best practice in shutdown project management at Trail. First, formal in-plant systems must be in place to monitor and manage condition of the major process equipment units. Second, the engineering and planning processes for every shutdown must begin as early as possible, and ensure full integration of required support groups such as the EH&S department, purchasing and contractors. Third, a strong shutdown management team working with robust systems is required to ensure contractors perform project work to plan, and to communicate necessary information to all participants in a timely manner. Fourth, follow up must take place following every shutdown to ensure that there is a systematic and continuous process of improving shutdown management.

Central management of standards and processes for the major Trail shutdowns is required to deliver improved and consistent results for the future. This is essential to ensuring the next generation will avoid the repeating failures of the past as members of the existing management team retire. This next generation will face sufficient challenges of its own to meet the demands for increasingly higher levels of performance, without needing to re-learning the lessons of the past.

Two important full time positions at Trail are required to provide additional leadership in shutdown management. All of the business areas at Trail Operations have the potential to benefit by creating a new full time role of shutdown project manager for the current smelter shutdown manager. Additionally, a full time shutdown EH&S manager is required to assist with improving management of shutdown environmental, health and safety aspects.

The roaster business area will achieve significant improvement in shutdown planning activities by establishing process integrity teams. Early identification of shutdown projects will result from a strong focus on process equipment condition. The team will manage front-end engineering to schedule rather than heavily relying on individual effort. Furthermore, these teams will prove useful for transferring process equipment knowledge to more members of the roaster management team. As the teams mature, the shutdown team will realize significant improvement in shutdown execution due to the application of quality assurance protocols.

A steering committee of management personnel is required to guide and direct the process of defining shutdown standards and processes for Trail Operations. This steering committee will develop a common vision and objectives for shutdown management at Trail. This committee will implement and oversee necessary change initiatives to improve shutdown management performance at Trail.

Now is the time for implementing this change. There are potential synergies with some of the major projects about to start at Trail Operations. Furthermore, upcoming retirements will lead to a loss of significant experience that will make this change more difficult in the future.

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