INTRODUCING AN IMPROVED PROCESS HAZARD ANALYSIS METHOD—ENGAGE, MOTIVATE, AND CHALLENGE YOUR TEAM

By
Dave Ego & Rosalynn MacGregor,
Dego Management Services Ltd.,
Kamloops, B.C., Canada

The intent of the Process Hazard Analysis (PHA) is to produce safer operating facilities by identifying process hazards and eliminating or reducing the risk of a hazardous event. The PHA is a legislative requirement in many jurisdictions for facilities that handle or store hazardous materials. Several drawbacks to the "traditional" PHA review approach are discussed in this article, and an improved method for conducting these reviews is introduced.

The unique PHA method introduced here is not software specific, but is based on a more visual, hands-on approach than most process safety professionals may have previously encountered. Over twelve years of practice has lead to the development of the efficient and effective techniques described here. The main features of this approach are:

- An accurate (field-checked) Process Hazard Drawing that contains all technical information needed to conduct the PHA;
- A systematic approach to developing lists of analysis questions that are created by following the flow on the Process Hazard Drawing;
- Active participation, promoted by the immediacy (in "operations language") of the analysis questions and the degree of visualization afforded by the Process Hazard Drawing;
- The generation of a record of answers to the analysis questions and a Recommendations Summary that stands the test of time and survives the ravages of personnel changes.
- Follow-up documentation, in the form of a PHA manual and technical data book, that is standardized, detailed, and easily understood. Revalidation and Management of Change are easily captured by the PHA manual.

RECENT HISTORY AND EVOLUTION OF PROCESS HAZARDS ANALYSIS

In response to increased severity and cost of losses of containment from hydrocarbon processing industry facilities, North American regulatory bodies and industry embarked on initiatives to reduce the number and severity of incidents. Process Safety Programs were developed and a list of Process Safety Elements evolved. The industrial community developed standards and procedures for each Process Safety element. Table 1 contains the main elements of the program:

Table 1: Process Safety Management Elements

Process Safety Management Policy	Operating Procedures
Process Hazard Analysis	Pre-Startup Safety Reviews
Process Safety Information	Emergency Response
Risk Assessment	Operator Training
Mechanical Integrity	Compliance Audits
Management of Change	Record Keeping/Document Control
Incident Investigation	Contractor Safety Assessments

The Process Hazard Analysis is the heart of the program and leads to a more logical approach in developing the other Process Safety elements. It is intended to be a rigorous review of the process to determine all potential uncontrolled losses of containment. In spite of the considerable efforts by the industry, preventable uncontrolled losses of containment continue to occur, even in facilities that have completed PHA reviews. Some of the many recent examples of uncontrolled losses include the release of large quantities of aromatic extracts to surface water, tank failures caused by internal explosions and the consequent release of toxic gases, and unburned flare gas releases affecting the surrounding public. As well, newly constructed facilities have not been immune to failure. At least one facility using leading edge process technology has been constructed with identifiable process hazard deficiencies, even after being subjected to a PHA review using commonly-used techniques and tools. Equipment modifications to correct the deficiencies after start-up added to the final costs.

The consequences of PHA failures have had some deleterious effects on the industry:

- Erosion of corporate credibility regarding protection of the public and employees;
- Reduced profitability due to hefty fines, legal fees, lost production, and lost productivity (as employees' efforts are diverted from the pursuit of enhanced business opportunities to addressing damage control, investigation, cleanup repairs, etc.);
- Continuation of an already-established trend in the news media to turn public opinion against industry;
- Erosion of confidence and credibility in the Process Safety Management approach; and
- Frustration of Process Safety and Management personnel due to a perception of improvements realized not being commensurate with the incurred costs.

FACTORS CONTRIBUTING TO PHA FAILURES

There are two typically-used approaches to PHA reviews:

- HAZOP: Hazard and Operability studies, in which specific points in a process ("item" or "node", often vessels, pumps, etc.) are focused on and an exhaustive series of questions is asked with the goal of identifying all of the things that could go wrong with the process at that point.
- "What-if" Analysis: Often used to analyze changes/additions to existing facilities, the engineer (and possibly others, depending on the project scope) asks himself all of the questions he can think of involving things that could go wrong with the equipment. Depending on the experience of the engineer, the review team make-up, team dynamics, etc., the number and nature of the questions asked may vary, and the method tends to lack the necessary rigor to fulfill the PHA objective.

The generally-accepted method worldwide for conducting rigorous PHA's is HAZOP (hazard and operability reviews). However, HAZOP reviews can be tedious for participants, particularly process operators. The reviews can also be very lengthy, costing companies significant man-hours. Worse, as stated above, process hazards have been missed during reviews, most of which are obvious in hindsight and should have been identified during the review meeting. Why were they missed?

Contributing factors in the failure to identify hazardous events are listed in Table 2.

Table 2: Why Commonly-used Process Hazards Analysis Techniques Fail

FAILURE CATEGORY	FAILURE	CONSEQUENCE
Poor Problem Definition	• Poor scope definition; failure to define start points and end points, exclusions and inclusions. • Failure to define process operating conditions (pressures, temperatures, compositions) explicitly. • Failure to define process throughputs (maximum, normal, turndown) explicitly.	Participants confused; time wasted; hazards incorrectly identified or missed
Imperfect Tools	P&IDs or MFDs (mechanical flow diagrams) require flipping through several drawings to determine the answer to a given deviation.	Team distracted, time wasted
	Inaccurate/out-of-date P&IDs (process and instrumentation diagrams) or MFD's (mechanical flow diagrams) (drawings are often out-of-date, at least to some degree, in jurisdictions not requiring them to be current)	Frustration for the PHA session leader and lost credibility with the Operations and Engineering PHA team members
	P&IDs or MFDs do not contain all information needed to evaluate a condition.	Time wasted, participants confused
Imperfect Approach	The 'item' or 'node' approach detracts from understanding the process flow.	Missed Process Hazards
	Shifting thinking logic by moving from hazard identification to risk assessment and then back again.	Team focus is diluted and team distracted from the identification of hazards—process hazards missed.
Organizational Challenges	Downsizing and limited human resources→ resistance of companies to establish/maintain departments with leadership dedicated to Process Safety Management	Impaired in-house PHA expertise and ability/drive to follow up on HAZOP recommendations
	Process Safety Management responsibilities added to existing organizations	Conflicting priorities within those organizations may cause Process Safety initiatives to "lose out"
	Movement of personnel into and out of PHA organizations (or the shifting of PHA responsibilities within an organization)	Impaired in-house PHA expertise and ability/drive to follow up on PHA review recommendations

CONSEQUENCES OF COMMONLY-USED PHA TECHNIQUES/TOOLS

There are three main areas that suffer negative consequences as a result of the factors listed in Table 2: PHA review team dynamics, PHA review meeting progress, and post-meeting documentation.

PHA Review Team Dynamics and Meeting Progress

Technical and Operations personnel often find the "item" or "node" approach to be mind-numbing after a few hours (sometimes even sooner). These employees are accustomed to dealing with real life issues in real time—valve failures, instrumentation failures, power outages, etc—that occur in an operating facility. The "item" or "node" approach is usually too far removed from their normal view of the process and its equipment, and many of the questions can seem to be redundant or pointless (too abstract).

The "item" or "node" approach also tends to be time-consuming. Participants are often more than willing to hurry the work, to "end the agony" and get back to their regular jobs. Time constraints on the meeting can also cause the PHA review team to rush their answers. Furthermore, the tedium discourages Operations and Engineering personnel from participating in subsequent Process Hazards Analysis reviews. Less than full PHA team participation and less than optimal product quality is the result—sometimes resulting in missed process hazards and/or deficiencies.

It can be difficult for the team to gauge progress during a review. Generally, the team is scheduled to meet for a set period of time, yet they may lack tools for easily determining whether they are half done at the half-way mark on the schedule, for instance. This adds a stressor to meeting dynamics.

PHA documentation

PHA documentation tends to consist of a massive collection of worksheets and a summary of deficiencies (or one or more disks of analogous computer files). The detailed PHA worksheets are time-consuming to revalidate. They are also frequently misplaced, partly due to their sheer bulk, but also because operating facility personnel find them of little use in day-to-day operations.

What PHA documentation often lacks is a final document that clearly describes all of the hazards found in a PHA review, along with all of the protective features that control those hazards. Complete knowledge of the facility's existing process hazards and the protection against failure is therefore not passed on to Operations and Engineering, *where it is most needed to prevent incidents*.

THE KEY TO SUCCESS—THE PROCESS HAZARD DRAWING

The authors have found that the use of a specialized visual tool is the key to overcoming the drawbacks suffered with commonly-used PHA tools and techniques. The Process Hazard Drawing (or PH Drawing; excerpts from some of the authors' file drawings are shown in Figures 1 and 2) is a specialized line drawing of the entire subject process unit. These drawings have allowed amazing efficiencies to be achieved, saving time and money[1], while simultaneously improving PHA review team participation. The result: more effective hazard identification, team members who want to come back for the next review, and recommendations that are implemented—in short, safer facilities.

With the PH Drawing, the problem definition is simpler: if it is on the drawing, it is within the scope of the review. All necessary information is on the drawing, giving it a

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[1] Adams, B., "Managing hazardous chemicals at Weyerhaeuser Kamloops," *Pulp & Paper Canada*, 2000, 101(4):T95-97.

clean, uncluttered appearance and eliminating distractions. A kick-off meeting is used to confirm the operating conditions that will apply for the review.

Preparation for the PHA review meeting is efficient and focused with the PH Drawing, since equipment that is on the diagram is field checked and its critical parameters verified and included (PSV set pressures, vessel design temperatures, pressures, routing of lines, locations of all valves, pump/compressor maximum shutoff pressures, etc.). Once the PH Drawing is created, a complete, structured set of analysis questions are generated by following the process flow. The complete analysis is systematically prepared prior to the holding the PHA review meeting. The drawing is subdivided into color-coded sections of piping and equipment, the pertinent analysis questions are assigned to these sections, and the sections are numbered for clarity. Each section is sized so that the team can complete the section in about an hour.

ADVANTAGES OF THE NEW METHOD

PHA Technique Improvements

The authors feel that the “item” or “node” approach is an imperfect way to look at a process facility, since it allows participants to examine parts of a facility in isolation from each other. Instead, to the maximum extent possible, the *process flow* should be followed, in context—the way Operations and Engineering personnel are accustomed to thinking about their facilities. This is a critical success factor of the new approach. It tends to engage, motivate, and challenge the PHA team members, leading to improved attention to detail. Often, the technique engenders friendly competition between team members to be the first to identify the process hazards associated with a specific failure—*it is fun*.

The PHA technique used by the authors usually keeps operability issues separate from process hazard concerns. Typically, a PHA review team is there to look for hazards. While it is commendable to improve the operability of a facility, the PHA review meeting may not the best forum to achieve this (unless operability concerns have deliberately been included in the scope of work). The objective of removing the operability issues from the PHA review is to reduce the time required to complete the PHA and to keep the focus on hazards identification. A “parking lot” document is created to capture operability issues that could improve operability.

It is also important that the PHA technique identifies all of the process hazards first, and then goes back to do risk analysis on those hazards during the same session. Different thought processes are used to identify hazards and to analyze risks; alternating between them tends to be inefficient and is often confusing to team members. This can harm the momentum of the review meeting, demotivating the participants.

PHA Meeting Time Duration

Optimizing the use of PHA meeting time keeps costs down, motivates participants, and produces the best quality results. As for most meetings, the best way to use every moment of the meeting constructively is to prepare well. Accurate information, as detailed above, reduces “wobbles” (and therefore delays) at the PHA review meeting.

After introductions, the PHA review team begins at the first section of the PH Drawing, pulling out the set of prepared analysis questions that applies to that section (refer to Figures 1 and 2 and Tables 3 and 4 for examples). A copy of the P&ID’s (or MFD’s) is usually available to the team to facilitate checking of a line size or a process control scheme and, of course, team members are encouraged to generate additional questions as the review proceeds. After completion of Section 1, Section 2 is begun, and so forth until the last section is completed.

PHA Meeting Time Management

The techniques and tools used by the authors for PHA facilitate time management during the review. By using the PH Drawing and the numbered analysis sections, the team is easily able to gauge its progress toward a defined goal. The techniques/tools used by the authors:

1) Allow for an accurate estimate of the time required to do the review;
2) Allow PHA team members to see their progress as the meeting proceeds (% complete versus schedule); and
3) Allow the PHA team members to determine early in the review whether they will finish ahead of or on schedule, or will need more time—and if so, why.

PHA Documentation

By referring to the PH Drawing throughout, the results of the PHA are documented in a PHA Manual generated by the authors. The PHA manual:

- Clearly describes the entire subject process;
- Clearly describes all of its process hazards;
- Clearly describes all of the protective features that control or prevent the hazards;
- Summarizes process hazards that are not currently protected against—in a way that promotes timely correction of deficiencies; and
- Is easily revalidated and updated.

The PH Drawing is a key part of the post-review meeting documentation and is and integral part of the PHA Manual.

CASE STUDY 1: LPG FACILITY

LPG's are stored in underground caverns at this facility and are processed in the plant prior to being shipped to market (see Figure 1 and Table 3). The PHA method introduced in this article was used in the early 1990's on this plant; a revalidation of the PHA was done, according to a master schedule, in the late 1990's. During the intervening years, a meter run was added (Section 4, in green, on Figure 1). The project included a process hazard analysis of the change; however, that analysis was flawed and failed to identify the significant overpressure concern identified on Table 3, item #'s 1, 3, and 8 (Risk level "A" represents the highest risk level for that facility). Fortunately, no incidents occurred prior to the revalidation, although the owners of the facility incurred significant cost to address the process hazard, once identified.

CASE STUDY 2: REFINERY (SHUTDOWN MODE)

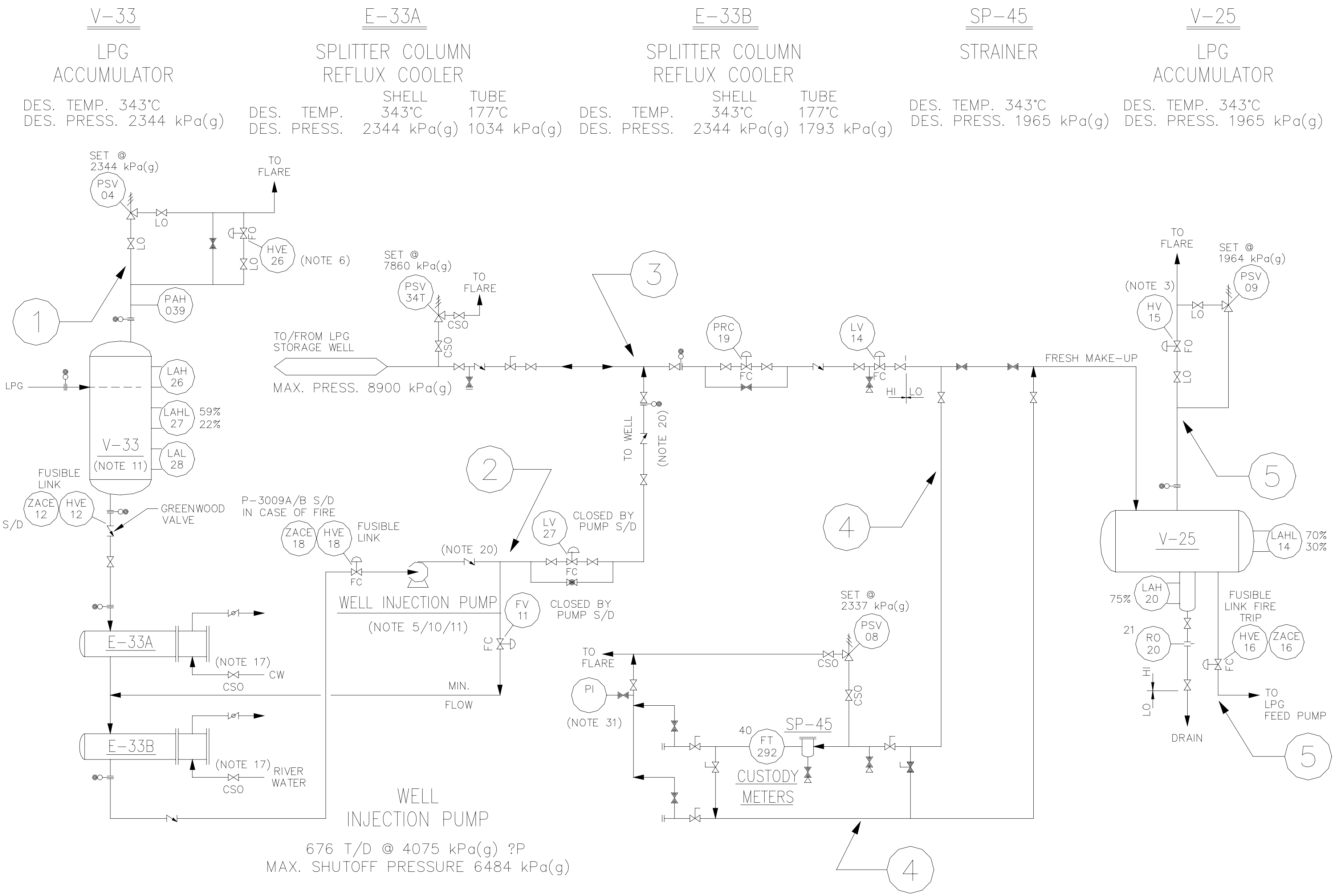
While PHA reviews generally attempt to cover all reasonable operating modes, it can be challenging to do the job well. The owners of this refinery (see Figure 2, Table 4) were planning a major shutdown and wanted to ensure that no significant process hazards were unidentified. Item #'s 7 and 8 identified the potential to overpressure the Extractor if hydrogen supplies (shown on Section 3 of Figure 2) were incorrectly isolated and emphasized the importance of this procedure to the owners. Item #9 identified the potential for storage tank damage due to hydrogen breakthrough—to a tank located a significant distance away from the subject process unit, and in another area of the refinery. (The ease of identifying hazards to downstream units is one of the unique strengths of the method presented in this article.) A recommendation to include vapor detection in the rundown line was not implemented, as reliance on the existing procedure was felt to be adequate for a "C" risk level. Unfortunately, the procedure was not properly followed during a subsequent refinery shutdown and significant costs were incurred by the owners to repair a sunken external floating roof; however, the owners were aware of the potential for failure and had consciously chosen to accept the risk of its occurrence.

CONCLUSION

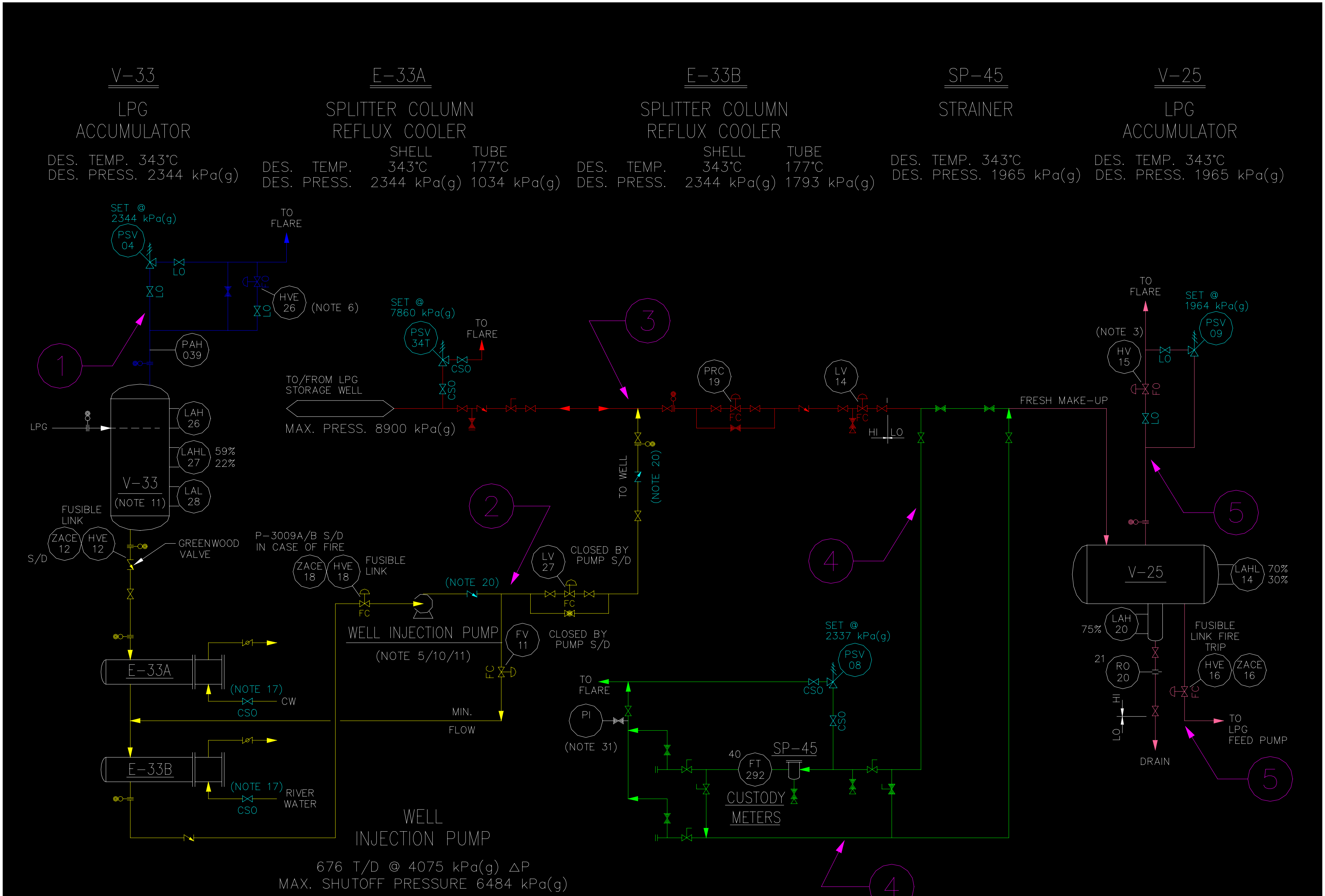
The systematic approach to PHA described here has these advantages over commonly-used PHA techniques and tools:

- It has been proven to identify more process hazards than any other method;
- It promotes and gains the buy-in of Operations and Engineering personnel (it is relatively easy to get participants for PHA review teams when this approach is used);
- It identifies all protective devices and procedures used to prevent/control all of the process hazards and documents this information in a useful package for operating facility personnel;
- It generates well-supported recommendations to address identified hazards;
- It facilitates "Management Of Change" by allowing the change to be quickly located and evaluated on the PH drawing; and
- It provides documents that are easily updated and revalidated.

These advantages make this new PHA method efficient, cost-effective, and thorough in identifying process hazards, toward fulfilling the goal of safer facilities.



V-33
LPG ACCUMULATOR
DES. TEMP. 343°C
DES. PRESS. 2344 kPa(g)
E-33A
SPLITTER COLUMN REFLUX COOLER
SHELL TUBE
DES. TEMP. 343°C 177°C
DES. PRESS. 2344 kPa(g) 1034 kPa(g)
E-33B
SPLITTER COLUMN REFLUX COOLER
SHELL TUBE
DES. TEMP. 343°C 177°C
DES. PRESS. 2344 kPa(g) 1793 kPa(g)
SP-45
STRAINER
DES. TEMP. 343°C
DES. PRESS. 1965 kPa(g)
V-25
LPG ACCUMULATOR
DES. TEMP. 343°C
DES. PRESS. 1965 kPa(g)
SET @ 2344 kPa(g)
PSV 04
TO FLARE
LO
HVE 26
(NOTE 6)
PAH 039
LPG
LAH 26
LAHL 27
59%
22%
V-33
(NOTE 11)
LAL 28
FUSIBLE LINK
ZACE 12
HVE 12
S/D
GREENWOOD VALVE
SET @ 7860 kPa(g)
PSV 34T
TO FLARE
CSO
TO/FROM LPG STORAGE WELL
MAX. PRESS. 8900 kPa(g)
TO WELL
(NOTE 20)
PRC 19
FC
LV 14
HI LO
FRESH MAKE-UP
TO FLARE
SET @ 1964 kPa(g)
PSV 09
(NOTE 3)
HV 15
V-25
LAHL 14
70%
30%
LAH 20
75%
21
RO 20
DRAIN
FUSIBLE LINK FIRE TRIP
HVE 16
ZACE 16
TO LPG FEED PUMP
P-3009A/B S/D IN CASE OF FIRE
ZACE 18
HVE 18
FUSIBLE LINK
LV 27
CLOSED BY PUMP S/D
WELL INJECTION PUMP
(NOTE 5/10/11)
FV 11
CLOSED BY PUMP S/D
E-33A
(NOTE 17)
CW
MIN. FLOW
E-33B
(NOTE 17)
RIVER WATER
SET @ 2337 kPa(g)
PSV 08
TO FLARE
PI
(NOTE 31)
40
FT 292
SP-45
CUSTODY METERS
1
2
3
4
5
WELL INJECTION PUMP
676 T/D @ 4075 kPa(g) ?P
MAX. SHUTOFF PRESSURE 6484 kPa(g)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LPG ACCUMULATOR
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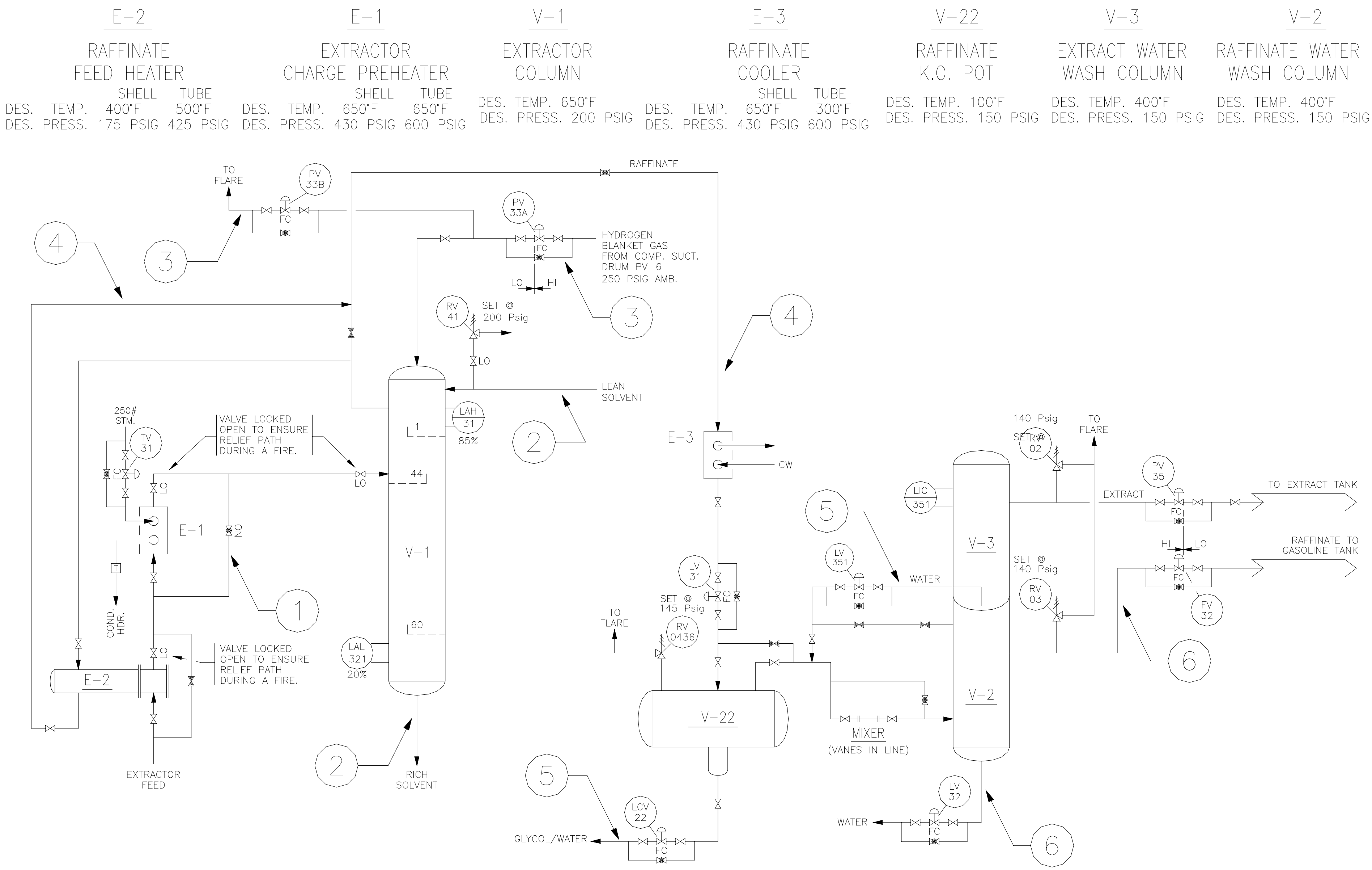
DES. PRESS. 2344 kPa(g)
E-33A
SPLITTER COLUMN REFLUX COOLER
SHELL TUBE
DES. TEMP. 343°C 177°C
DES. PRESS. 2344 kPa(g) 1034 kPa(g)
E-33B
SPLITTER COLUMN REFLUX COOLER
SHELL TUBE
DES. TEMP. 343°C 177°C
DES. PRESS. 2344 kPa(g) 1793 kPa(g)
SP-45
STRAINER
DES. TEMP. 343°C
DES. PRESS. 1965 kPa(g)
V-25
LPG ACCUMULATOR
DES. TEMP. 343°C
DES. PRESS. 1965 kPa(g)
SET @ 2344 kPa(g)
PSV 04
LO
TO FLARE
HVE 26
(NOTE 6)
PAH 039
LAH 26
LAHL 27
59%
22%
LAL 28
V-33
(NOTE 11)
LPG
FUSIBLE LINK
ZACE 12
HVE 12
S/D
GREENWOOD VALVE
SET @ 7860 kPa(g)
PSV 34T
CSO
TO FLARE
TO/FROM LPG STORAGE WELL
MAX. PRESS. 8900 kPa(g)
PRC 19
FC
LV 14
HI LO
FRESH MAKE-UP
TO WELL
(NOTE 20)
(NOTE 3)
TO FLARE
SET @ 1964 kPa(g)
PSV 09
HV 15
FO
P-3009A/B S/D IN CASE OF FIRE
ZACE 18
HVE 18
FUSIBLE LINK
LV 27
CLOSED BY PUMP S/D
WELL INJECTION PUMP
(NOTE 5/10/11)
FV 11
CLOSED BY PUMP S/D
E-33A
(NOTE 17)
CW
MIN. FLOW
E-33B
RIVER WATER
V-25
LAHL 14
70%
30%
LAH 20
75%
FUSIBLE LINK FIRE TRIP
21
RO 20
HVE 16
ZACE 16
TO LPG FEED PUMP
DRAIN
SET @ 2337 kPa(g)
PSV 08
TO FLARE
PI
(NOTE 31)
40
FT 292
SP-45
CUSTODY METERS
WELL INJECTION PUMP
676 T/D @ 4075 kPa(g) ΔP
MAX. SHUTOFF PRESSURE 6484 kPa(g)
1
2
3
4
5

4/24/2003

Project: New Custody Meter for LPG – Process Hazard Analysis Revalidation				**Section:** 4	**Page:** 1
Section Description: Meter run for LPG stream from Splitter Unit to Preparation Unit					
NUMBER	**FAILURE MODE**	**POSSIBLE HAZARD**	**CURRENT PROTECTION**	**Remarks & Recommendation**	**Risk**
1.	Block valve in the meter line at the pipe rack is left closed after a shutdown.	Overpressure piping with wellhead pressure leading to line failure or gasket leaks. LPG leaks may create a vapor cloud and explosion.	No current protection. Piping is not designed for wellhead pressure.	Consider locking valve open for immediate short-term solution. Long Term replace piping to meet pressure rating.	A
2.	Block valve on the inlet to Strainer SP-45 passes when the strainer is open for maintenance?	Uncontrolled loss of containment exposing personnel to fire and toxic hazard.	Operating procedure calls for checking pressure before opening system to atmosphere.	Verify pressure gages are in place in field.	B
3.	SP-45 strainer plugs	Overpressure upstream piping and strainer with wellhead pressure. PSV-08 is for thermal relief and will not protect system for blocked flow. (PRV4080 set higher than equip design press).	No current protection. Piping and strainer are not designed for wellhead pressure.	Consider changing strainer and piping to meet the maximum pressure from wellhead.	A
4.	Block valve on the outlet of Strainer SP-45 is left closed?	Overpressure upstream piping and strainer with wellhead pressure.	No current protection. Piping and strainer are not designed for wellhead pressure. (monthly meter proving increases hazard probability).	Consider changing strainer and piping to meet the maximum pressure from wellhead.	
5.	Strainer SP-45 is left blocked in when not in use.	Possible overpressure due to thermal expansion.	PSV-08 provides thermal expansion protection (required due to long length of piping)		
6.	Block valve to flare left open after meter proving.	LPG will flow to the flare. Flare may plug due to hydrate formation. Piping may fracture due to cold temperatures.	Unit Flare KO drum protects against liquid to flare. The Operator will detect Excessive flaring. Meter proving procedures reduce the risk.		

Project: New Custody Meter for LPG – Process Hazard Analysis Revalidation				**Section:** 4	**Page:** 2
Section Description: Meter run for LPG stream from Splitter Unit to Preparation Unit					
NUMBER	**FAILURE MODE**	**POSSIBLE HAZARD**	**CURRENT PROTECTION**	**Remarks & Recommendation**	**Risk**
7.	Meter Prover flex hoses rupture or coupling comes apart while proving meter.	Uncontrolled loss of containment exposing personnel to fire and toxic hazard. Escaping LPG may create a vapor cloud and explosion.	Couplings are locked after connecting. System is pressure tested with Nitrogen Hoses are inspected and tested annually.	Consider emergency isolation valves on inlet and outlet of meter run piping.	A
8.	Return line block valve on meter prover closed while connected to process.	Overpressure of piping, hoses, meter equipment and proving truck with wellhead pressure.	No current protection. Piping and meter system are not designed for wellhead pressure. (Monthly meter proving increases hazard probability).	Check the meter prover truck and hoses design pressure for max pressure from wellhead. Consider changing strainer and piping to meet the maximum pressure from wellhead.	A
9.	Meter proving truck moves while connected to process.	Hose break uncontrolled loss of containment exposing personnel to fire and toxic hazard. Escaping LPG may create a vapor cloud and explosion.	Operating procedure calls for chocking of truck wheels, application of the emergency brake, engine shut-off and traffic barricades.	Review procedure for safety steps. Consider emergency isolation valves on inlet and outlet of meter run piping.	A


E-2
RAFFINATE FEED HEATER
SHELL TUBE
DES. TEMP. 400°F 500°F
DES. PRESS. 175 PSIG 425 PSIG
E-1
EXTRACTOR CHARGE PREHEATER
SHELL TUBE
DES. TEMP. 650°F 650°F
DES. PRESS. 430 PSIG 600 PSIG
V-1
EXTRACTOR COLUMN
DES. TEMP. 650°F
DES. PRESS. 200 PSIG
E-3
RAFFINATE COOLER
SHELL TUBE
DES. TEMP. 650°F 300°F
DES. PRESS. 430 PSIG 600 PSIG
V-22
RAFFINATE K.O. POT
DES. TEMP. 100°F
DES. PRESS. 150 PSIG
V-3
EXTRACT WATER WASH COLUMN
DES. TEMP. 400°F
DES. PRESS. 150 PSIG
V-2
RAFFINATE WATER WASH COLUMN
DES. TEMP. 400°F
DES. PRESS. 150 PSIG
TO FLARE
PV 33B
FC
RAFFINATE
PV 33A
FC
HYDROGEN BLANKET GAS FROM COMP. SUCT. DRUM PV-6 250 PSIG AMB.
LO HI
RV 41
SET @ 200 Psig
LO
LEAN SOLVENT
250# STM.
TV 31
FC
LO
VALVE LOCKED OPEN TO ENSURE RELIEF PATH DURING A FIRE.
LAH 31
85%
1
44
LO
E-1
NO
V-1
COND. HDR.
60
LAL 321
20%
E-2
VALVE LOCKED OPEN TO ENSURE RELIEF PATH DURING A FIRE.
EXTRACTOR FEED
RICH SOLVENT
E-3
CW
LV 31
SET @ 145 Psig
FC
TO FLARE
RV 0436
V-22
LCV 22
FC
GLYCOL/WATER
140 Psig
SET @
RV 02
TO FLARE
LIC 351
PV 35
EXTRACT
FC
TO EXTRACT TANK
HI LO
RAFFINATE TO GASOLINE TANK
SET @ 140 Psig
RV 03
FC
FV 32
LV 351
FC
WATER
V-3
V-2
MIXER
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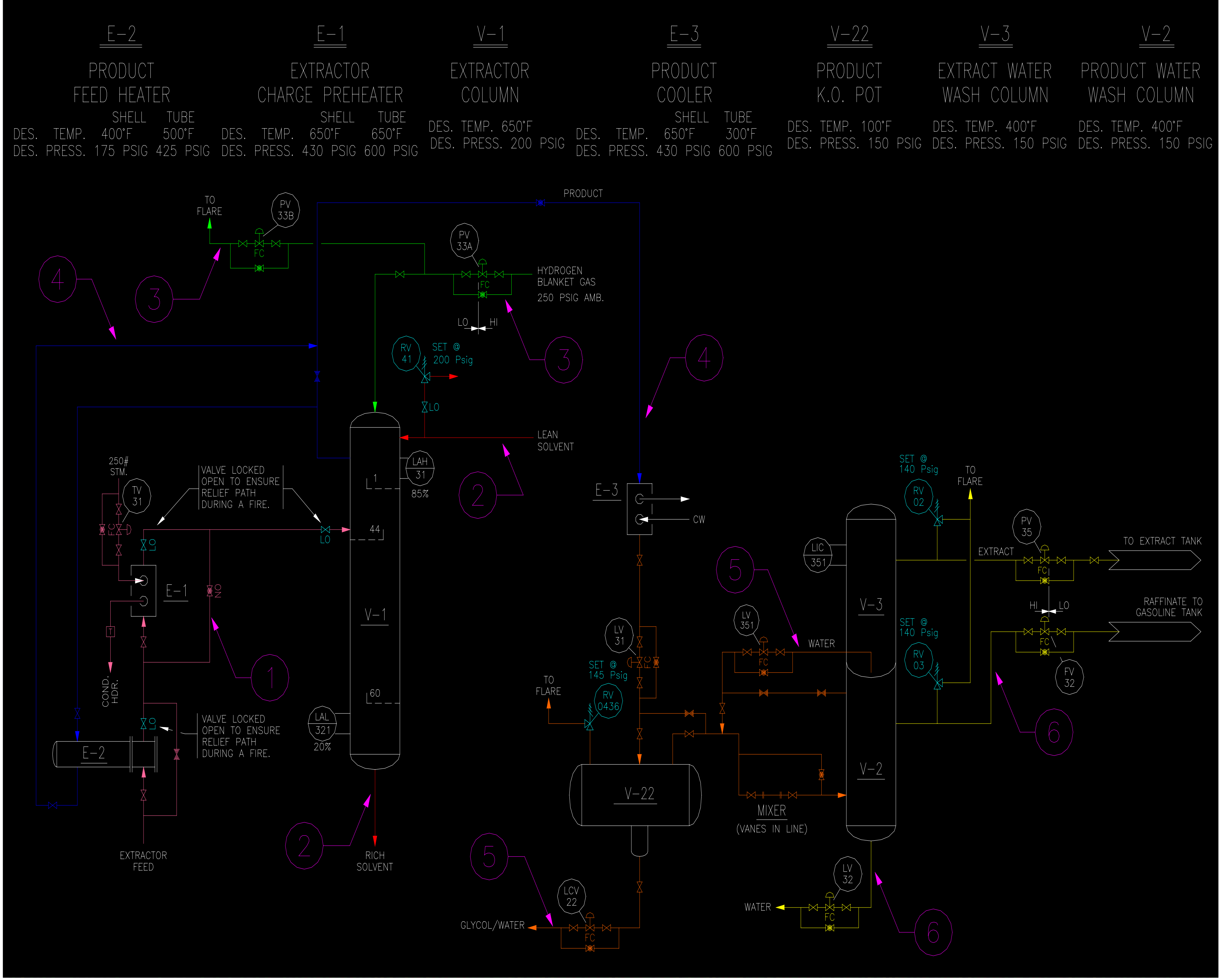
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EXTRACTOR CHARGE PREHEATER
SHELL TUBE
DES. TEMP. 650°F 650°F
DES. PRESS. 430 PSIG 600 PSIG
V-1
EXTRACTOR COLUMN
DES. TEMP. 650°F
DES. PRESS. 200 PSIG
E-3
PRODUCT COOLER
SHELL TUBE
DES. TEMP. 650°F 300°F
DES. PRESS. 430 PSIG 600 PSIG
V-22
PRODUCT K.O. POT
DES. TEMP. 100°F
DES. PRESS. 150 PSIG
V-3
EXTRACT WATER WASH COLUMN
DES. TEMP. 400°F
DES. PRESS. 150 PSIG
V-2
PRODUCT WATER WASH COLUMN
DES. TEMP. 400°F
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TO FLARE
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FC
PRODUCT
PV 33A
HYDROGEN BLANKET GAS 250 PSIG AMB.
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RV 41
SET @ 200 Psig
LO
LEAN SOLVENT
LAH 31
85%
250# STM.
TV 31
FC
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VALVE LOCKED OPEN TO ENSURE RELIEF PATH DURING A FIRE.
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E-1
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COND. HDR.
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20%
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VALVE LOCKED OPEN TO ENSURE RELIEF PATH DURING A FIRE.
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EXTRACTOR FEED
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E-3
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RV 02
TO FLARE
PV 35
TO EXTRACT TANK
EXTRACT
FC
LIC 351
V-3
HI LO
RAFFINATE TO GASOLINE TANK
SET @ 140 Psig
RV 03
FC
FV 32
LV 351
FC
WATER
LV 31
FC
SET @ 145 Psig
RV 0436
TO FLARE
V-22
MIXER (VANES IN LINE)
V-2
LCV 22
GLYCOL/WATER
FC
LV 32
WATER
FC
1
2
2
3
3
4
4
5
5
6
6

Project: Product Extract Unit Shutdown – Process Hazard Analysis Revalidation				**Section:** 3	**Page:** 1
Section Description: Hydrogen Blanket and pressure control for Extractor Tower					
NUMBER	**FAILURE EVENT**	**POSSIBLE HAZARD**	**CURRENT PROTECTION**	**Remarks & Recommendation**	**Risk**
1.	Hydrogen pressure is lost during unit shutdown.	Back flow of Product liquids into hydrogen system.	Procedures for shutting down the unit include isolating the hydrogen pressure control from the Extractor Tower and stopping the Product flow into the Tower. Level control continues to maintain liquid level preventing liquid from rising to the hydrogen inlet. Hydrogen system is highly reliable.		
2.	Hydrogen pressure increases during a unit shutdown.	Not a credible event.			
3.	Hydrogen temperature increases during a unit shutdown.	No hazard. Temperature changes limited to ambient conditions.			
4.	Hydrogen temperature decreases during a unit shutdown.	No hazard. Temperature changes limited to ambient conditions.			
5.	Hydrogen gas is contaminated during a unit shutdown. (i.e. water, hydrocarbon, etc.)	No hazard is created for Product Extractor.			
6.	Control valve PV-33A in the hydrogen blanket gas to the Extractor Column fails closed during a unit shutdown.	No hazard.			
7.	Control valve PV-33A in the hydrogen blanket gas to the Extractor Column fails open during a unit shutdown.	Overpressure Extractor column.	Protected by RV-41. No credit is taken for shutdown procedures that include isolation the hydrogen system during the shutdown.	Verify relief load created by PV-33A failing open.	B

Project: Product Extract Unit Shutdown – Process Hazard Analysis Revalidation				**Section:** 3	**Page:** 2
Section Description: Hydrogen Blanket and pressure control for Extractor Tower					
NUMBER	**FAILURE MODE**	**POSSIBLE HAZARD**	**CURRENT PROTECTION**	**Remarks & Recommendation**	**Risk**
8.	By pass around control valve PV-33A in the hydrogen blanket gas to the Extractor Column is left open during a unit shutdown.	Overpressure Extractor column.	Protected by RV-41. No credit is taken for shutdown procedures that include isolation the hydrogen system during the shutdown.	Verify relief load created by leaving bypass open around PV-33A.	B
9.	Block valve in the line to the top of the Extractor Column V-1 is left open during a shutdown.	Hydrogen gas will flow through the Product Extractor system to the storage tank leading to tipping and sinking of the external-floating roof. Loss of floating roof will allow volatile vapors to escape to atmosphere creating a vapor cloud and fire hazard.	Shutdown procedures include isolating the unit at the battery limit block valves and checking system pressure to ensure system is depressured.	Consider vapor detection in the rundown line to the storage tank.	C
10.	Control valve PV-33B in the line to flare from the Extractor Column fails closed during a unit shutdown.	No hazard.			
11.	Control valve PV-33B in the line to flare from the Extractor Column fails open during a unit shutdown.	Liquid to the flare leading to potential for liquid hammer during a major release, excessive flaring, reduced relief capacity during a major event.	Procedures for shutting down the unit include isolating the hydrogen pressure control from the Extractor Tower and stopping the Product flow into the Tower. Level control continues to maintain liquid level preventing liquid from rising to the hydrogen inlet.		
12.	By pass around control valve PV-33A in the hydrogen blanket gas to the Extractor Column is left open during a unit shutdown.	Overpressure Extractor column.	Protected by RV-41. No credit is taken for shutdown procedures that include isolation the hydrogen system during the shutdown.		

List of Tables and Figures

Author bylines

Dave Ego holds a B. Sc. In Mechanical Engineering from the University of Alberta, 1974 and has served with the Canadian Military Engineers until 1979. Dave spent several years at Dow Chemical facilities in Fort Saskatchewan before joining Endeco Engineering as a manager in 1983. As manager of a multi-discipline engineering team, Dave directed the day-to-day engineering activities at Syncrude Canada for a variety of projects. Dave formed Dego Management Services Inc. (www.dego.org) in 1986 specializing in Process Safety. Starting with the Guide Word HAZOP technique, Dego Management has performed many PHAs and used the experiences to develop the technique now in use today. Dave and his team continue to provide process safety services to a variety of clients.

Rosalynn J. MacGregor holds a B.A.Sc. in Chemical Engineering from the University of British Columbia and a M.Sc. in Chemical Engineering from the University of Alberta. She worked for Shell Canada for 15 years, 13 of them in operating locations in Alberta: Scotford Refinery near Edmonton, Peace River Complex (in-situ bitumen thermal extraction), and the Jumping Pound Gas Plant near Calgary. Rosalynn spent 2 years in the Shell Canada head office process engineering group, but her clear preference is for operating locations. Positions she held with Shell include process engineer, operations engineer, and technical superintendent. Rosalynn joined Dego Management in 2001 as leader of their technical department (www.dego.org).