Piping Circuitization and Risk-Based Inspection Requirements

by Lynne Kaley, P.E.

- Materials/Corrosion and Risk Management Engineer
- 30 Years Refining, Petrochemical and Midstream Gas Processing Experience
- Leader in Risk-Based technology development for plant applications
- Project Manager of API RBI Joint Industry Project since 1996
- Member of API committees for development of API 580 and API 581 recommended practices
- Developer and Official Trainer for API 580/581 Public Training course
- Vice President and Principal Engineer with Equity Engineering

The Equity Engineering Group, Inc.

Purpose

- Purpose of Presentation
  - Using API 580 and 581 for piping Risk Assessment
  - Systemization and circuitization of piping
  - Understand complementary nature of Materials Operating Envelopes (MOE)
  - Understand challenges of piping inspection
- Sources
  - API RBI User Group Joint Industry Project
  - API 580
  - API 581
  - API 570
  - API 571
  - API RBI Software

Presentation Outline

- Introduction
- Piping Programs Characteristics
- Available Analysis Tools
- A Complementary Approach: Material Operating Envelopes (MOE)
- Piping Systemization and Circuitization
  - Piping study case study 1
  - Piping study case study 2
- Piping TML Data Analysis & Benefits
- Summary & Conclusions

The Goal

Assure regulatory and corporate compliance, and ensure reliable use of piping (and equipment) for finite run times, while measuring, managing and minimizing risks and eliminating non-value adding activities and costs.

Introduction

- Historical industry statistics attribute piping failure to be leading cause of large property losses
- Industry data indicates that the most frequent unexpected failures occur in piping systems (30-45%) due to localized corrosion, often by undetected mechanisms
- The majority of industry piping programs use a classification system from API 570 for criticality ranking
- Straight beam ultrasonic inspection (UT) is the most commonly used method for thinning damage detection
- Quality of inspection data, coverage of inspection points and a link of inspection locations and type to damage mechanism must be analyzed to assure program effectiveness
- Correct CML/TML placement needs to be determined in conjunction with active damage mechanisms identified by experienced corrosion/materials engineer

*Reference Marsh & McLennan, API Rand and E[2]G studies.

Introduction

- *"Losses in the refinery industry have continued to increase over the last few years and the causes highlight the aging facilities in this category. A significant number of larger losses (over $10,000,000) have been caused by piping failures or piping leaks, leading to fires and/or explosions. Several large losses due to piping failures were due to corrosion issues or using the wrong metallurgy….."*

From the Marsh and McLennan Report, *The 100 Largest Losses 1972-2001*, 20th Edition: February 2003, a publication of Marsh's Risk Consulting Practice

Introduction

The explosion occurred when employees were attempting to isolate a leak on a condensate line between the NGL plant and the refinery. Three crude units were damaged and two reformers were destroyed. The fire was extinguished approximately nine hours after the initial explosion. Five people were killed and 50 others were injured. Initial investigation into the loss indicates a lack of inspection and maintenance of the condensate line.

June 25, 2000
Mina Al-Ahmadi, Kuwait
$412,000,000 (2000 dollars)

From the Marsh and McLennan Report, *The 100 Largest Losses 1972-2001*, 20th Edition: February 2003, a publication of Marsh's Risk Consulting Practice

Introduction

- Routine straight beam ultrasonic inspection (UT) is by far the most common method (and often the only) of inspection independent of the expected damage mechanism assessment

- Often a detailed analysis of the UT data is not done to determine the quality of the data, adequate coverage of inspection points, etc.

Introduction

- Most refining, mid-stream, and chemicals pressurized equipment was designed and built for an operating basis different than current operation
- Plants continuously “tweak” the process to raise throughput or process poorer quality (lower cost) feedstocks (crudes or intermediates)
- Long term effect is cumulative so that minor changes may cause a significant increase in damage rates

Piping Programs

- CMLs must be placed in the correct locations, and used with appropriate NDE
  - Guidance/Input from corrosion engineers for placement decisions
  - RBI not used to quantify risk reduction/investment payback
  - Use statistics as applicable to determine optimal sampling
- An overabundance of CMLs results in non-value-added activities
- Integrate and define the value of corrosion reviews, Fitness for Service evaluations, RBI and statistical analyses in the inspection and planning process for optimal effectiveness

Piping Programs

- Considerations for Inspection Database programs (IDBMS)
  - How much change has occurred between measurements?
  - How accurate are the measured corrosion rates?
  - How do we use retirement dates (based on ½ life)?
  - What the basis for retirement limit (nominal + CA)?
  - How was the program initially set-up?
  - How were circuits defined?
  - Was corrosion and expected damage mechanisms used for defining inspection scope, type and location?
- Plants are aging
  - Failure rates will increase without effective change

Piping Programs

- Requires a shift from original basis to consider why, where, when, how to inspect
- RBI Principles
  - Qualitatively grade the effectiveness of NDE
  - Probability of failure involves uncertainty
  - Consequence
- FFS Principles
  - Limiting flaw size
  - Accuracy of NDE
- Proactive approaches
  - Corrosion systemization and circuitization
  - Operating Envelopes (MOEs)
  - Management of Change (MOCs)

Available Tools

- Codes & Standards permit use of and provide minimum guidelines for
  - RBI
  - FFS
  - Jurisdictional

- Supporting documents
  - 580
  - 581
  - API/ASME ISIJC

Available Tools

- Codes and Standards
  - Latest editions of API 570, 574, 579, 580, 581
- RBI
  - Damage mechanism assignment is a critical element
- FFS
  - Engineering Analysis
  - Damage mechanism assignment is a critical element
- Corrosion and materials review
  - Systemization and circuitization
  - RBI damage mechanism assignment
  - MOE

Available Tools

- Materials/corrosion review with assignment of active damage mechanisms
  - Critical to the success of any equipment reliability program
  - Critical to success of any RBI process
  - Required by codes, standards and regulators
  - Should include special emphasis mechanisms (e.g., Stress Corrosion Cracking, Creep, Wet H_2S)

When to Consider an MOE

- Complimentary Approach: Material Operating Envelopes (MOE)
- Proactively or in response to an incident
- In conjunction with a critical Fitness-For-Service assessment
- Next step after doing RBI

Materials Operating Envelopes

- Identify key parameters and ranges
- Traditional piping inspection programs rely on future operating conditions replicating past operating conditions
- RBI typically focused more on inspection activities than on controlling operations and identifying monitoring activities
- Knowledge and control of operating envelope helps provide an improved chance for reliability and safety, due to increasing knowledge of actual operating parameters
- An MOE defines the envelope for predictable degradation versus specific operating parameters

Defining Limits

- Similar to KPRP's
- Contain some parameters that may not be controllable, but must be measured and trended
- Defines limits operation (feed contaminant content, pH, flow rate, temperatures, chemical or water injection rates) and acceptable levels of corrosive constituents
- Control of operating parameters to minimize corrosion/degradation
- Modeling required with sampling/inspection to verify assumptions about constituents or conditions not being present
- Limits exceeded and degradation accelerated may trigger inspection, RBI, FFS updates or other actions

Inspection Benefits of MOE

- Identify need for more UT coverage in some areas and less in other areas
- Identify improper inspection procedures being applied
- Identify equipment taken out of service with blinding points that create process deadlegs
- Identify equipment being cycled in/out of service creating CUI concerns

Piping Circuitization

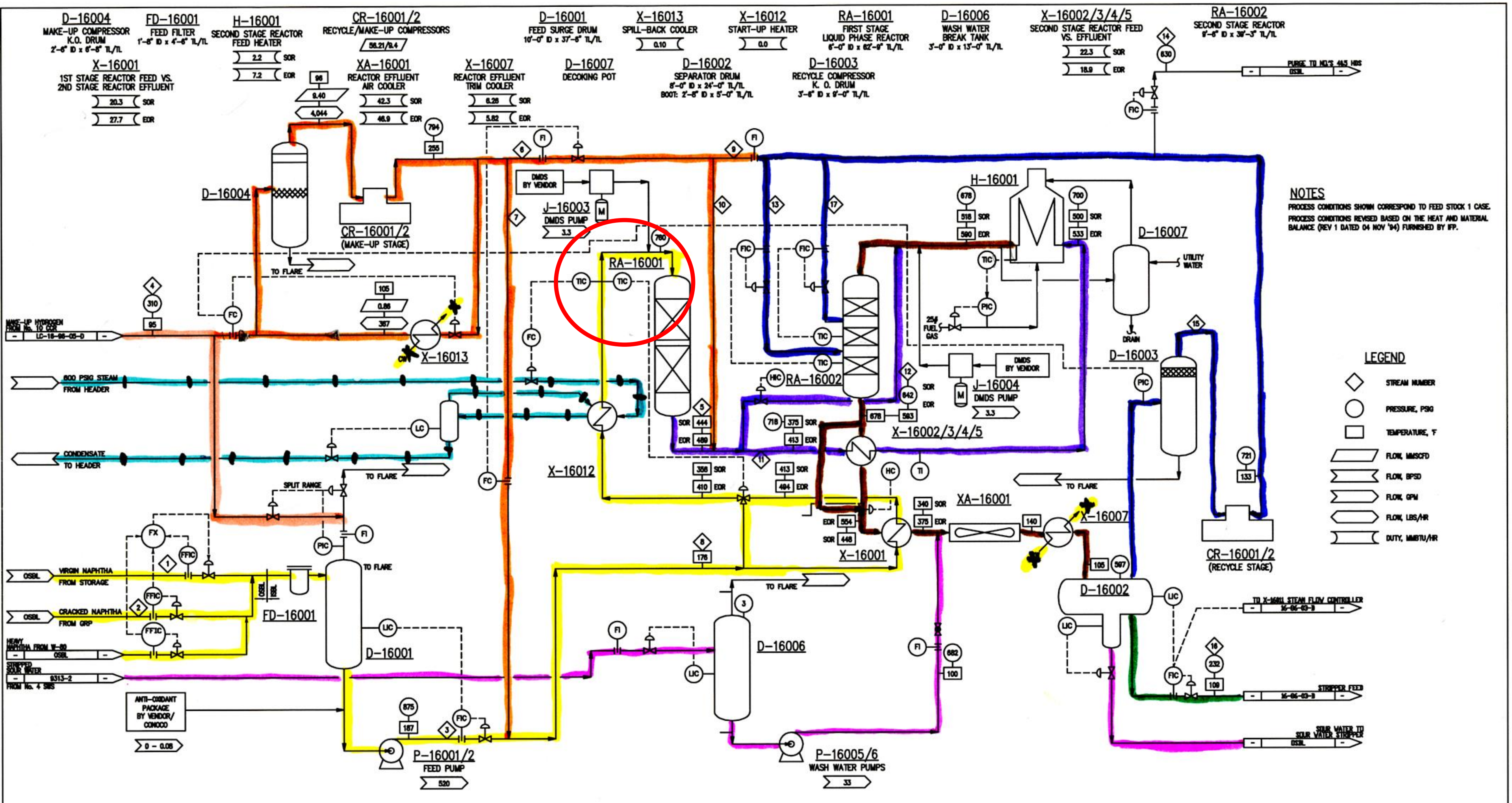
- Use an experienced corrosion/materials engineer to define systems in each unit
- Define corrosion circuits within each system based on materials of construction, operating conditions and active damage mechanisms
- Circuit identification and naming convention is used for both API RBI and IDBMS programs to provide linking and sharing inspection data
- Analysis is performed on circuit inspection results to determine circuit corrosion rate and measured thickness/dates for circuit components
- Circuit corrosion rates are used in API RBI to calculate circuit risk
- Determine the circuit and component next inspection date and inspection effectiveness, including detailed inspection plan
- Review or Placement of CML/TML recommended by corrosion/materials engineer
- CML/TML installed and documented on piping Isometric drawings

Example 1

HDS Unit

System Key – HDS

1) HDS Feed
2) 1st Stage Reactor & Effluent
3) 2nd Stage Reactor & Effluent
4) Recycle Hydrogen & Effluent
5) Make-up Hydrogen
6) Naphtha Stripper Feed
7) Naphtha Stripper Overhead & Reflux
8) Naphtha Stripper Bottoms & Reboiler
9) CCR Feed
10) #1 Reactor Feed Effluent
11) #2 Reactor Feed Effluent
12) #3 Reactor Feed Effluent
13) #4 Reactor Feed Effluent
14) Reformer Recycle Hydrogen
15) Net Gas Compression
16) Net Gas Chloride Treaters
17) LPG Recovery Propane Compression & Chiller
18) Debutanizer Feed
19) Debutanizer Overhead & Reflux
20) Debutanizer Bottoms & Reboiler
21) Benzene Overhead & Reflux
22) Benzene Aromatic Product
23) Benzene Bottoms & Reboiler



FEED STOCK 1 START OF RUN

STREAM NO. / DESCRIPTION	1 NAPHTHA FROM STORAGE	2 NAPHTHA FROM GRP	3 COMBINED FEED	4 H_2 FROM REFORMER	5 REACTOR 1 OUTLET	6 H_2 MAKE-UP TO REACTOR 2	7 H_2 MAKE-UP TO REACTOR 1	8 X-16001 INLET	9 H_2 RECYCLE	10 MAKE-UP & RECYCLE H_2 TO RA-16002	11 X-16002/3/4/5 INLET	12 RA-16002 OUTLET	13 RA-16002 H_2 QUENCH	14 H_2 PURGE	15 RECYCLE COMPRESSOR INLET	16 STRIPPER FEED	17 RA-16002 H_2 QUENCH
LBS/HR	30,049	132,873	162,922	3,676	164,565	2,033	1,644	164,565	9,254	11,287	175,852	201,583	10,856	352	35,318	166,246	14,856
MMSCFD	–	–	–	8.53	–	4.72	3.82	–	14.73	19.45	–	73.58	17.28	0.56	56.21	–	23.64
BPSD	2,800	12,200	15,000	–	–	–	–	–	–	–	–	–	–	–	–	–	–
MW	101	101	93	3.9	83.4	3.9	3.9	75.7	5.7	5.3	42.8	25	5.7	5.7	5.7	87.2	5.7
API	60.8	58.2	58.7	–	–	–	–	–	–	–	–	–	–	–	–	–	–

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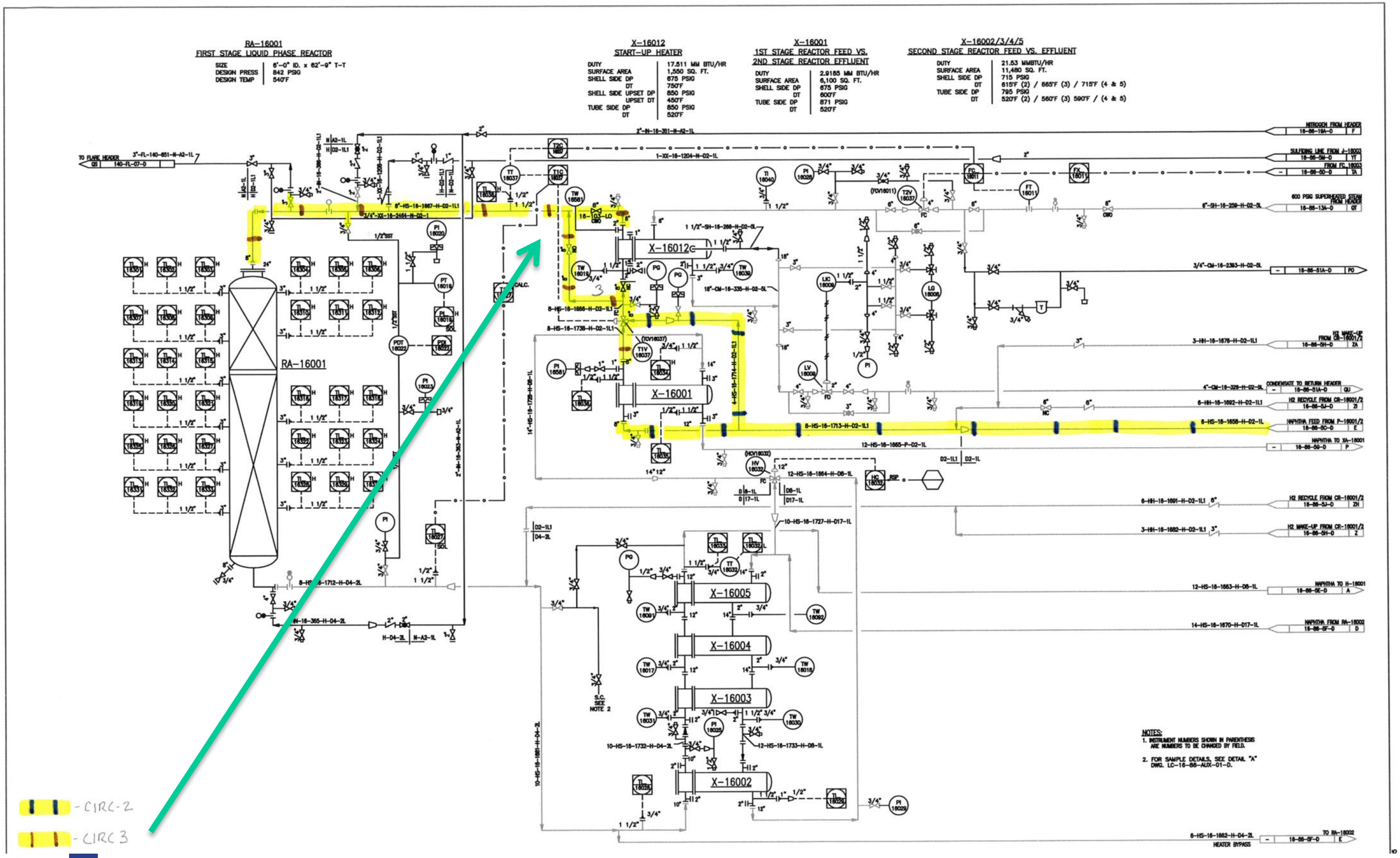
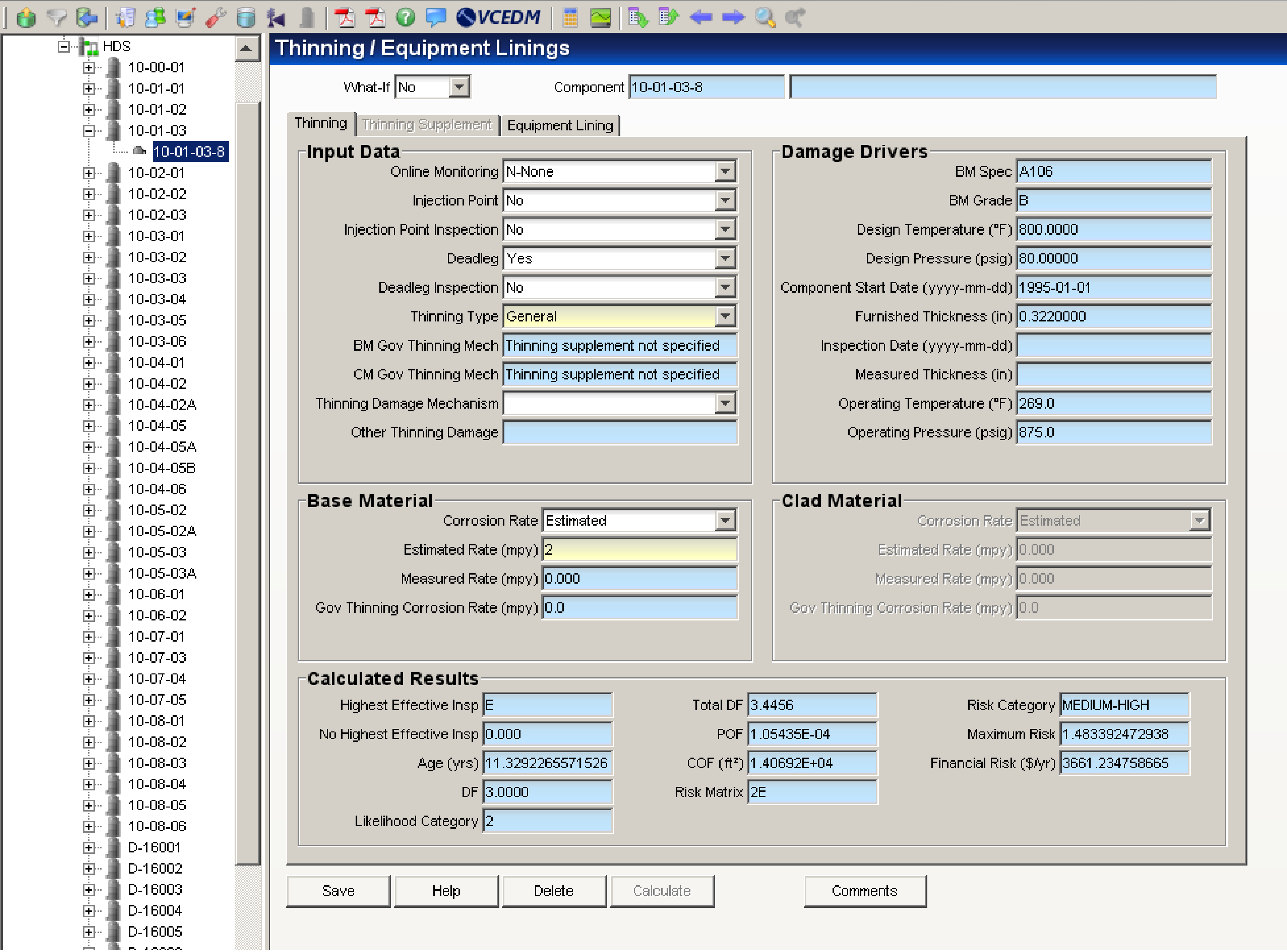
MMSCFD	–	–	–	8.53	–	4.72	3.82	–	14.73	19.45	–	63.62	15.56	0.56	46.23	–	15.56
BPSD	2,800	12,200	15,000	–	–	–	–	–	–	–	–	–	–	–	–	–	–
MW	101	101	93	3.9	83.4	3.9	3.9	75.7	5.7	5.3	42.8	28	5.7	5.7	5.7	87.2	5.7
API	60.8	58.2	58.7	–	–	–	–	–	–	–	–	–	–	–	–	–	–

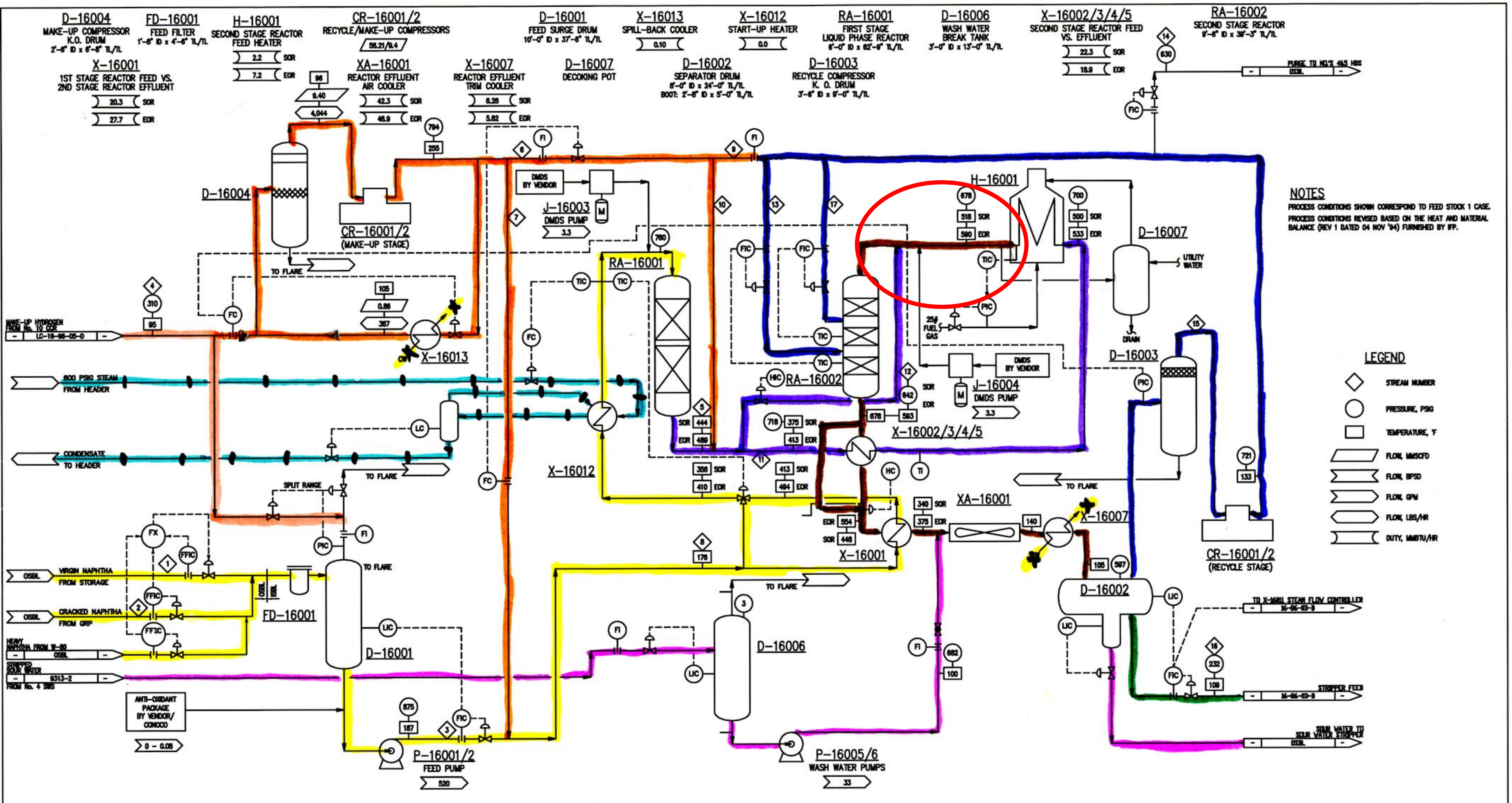


RA-16001
FIRST STAGE LIQUID PHASE REACTOR
X-16012
START-UP HEATER
X-16001
1ST STAGE REACTOR FEED VS. 2ND STAGE REACTOR EFFLUENT
X-16002/3/4/5
SECOND STAGE REACTOR FEED VS. EFFLUENT
X-16005
X-16004
X-16003
X-16002
- CIRC-2
- CIRC 3


VCEDM
HDS
10-00-01
10-01-01
10-01-02
10-01-03
10-01-03-8
10-02-01
10-02-02
10-02-03
10-03-01
10-03-02
10-03-03
10-03-04
10-03-05
10-03-06
10-04-01
10-04-02
10-04-02A
10-04-05
10-04-05A
10-04-05B
10-04-06
10-05-02
10-05-02A
10-05-03
10-05-03A
10-06-01
10-06-02
10-07-01
10-07-03
10-07-04
10-07-05
10-08-01
10-08-02
10-08-03
10-08-04
10-08-05
10-08-06
D-16001
D-16002
D-16003
D-16004
D-16005
Thinning / Equipment Linings
What-If No
Component 10-01-03-8
Thinning
Thinning Supplement
Equipment Lining
Input Data
Online Monitoring N-None
Injection Point No
Injection Point Inspection No
Deadleg Yes
Deadleg Inspection No
Thinning Type General
BM Gov Thinning Mech Thinning supplement not specified
CM Gov Thinning Mech Thinning supplement not specified
Thinning Damage Mechanism
Other Thinning Damage
Damage Drivers
BM Spec A106
BM Grade B
Design Temperature (°F) 800.0000
Design Pressure (psig) 80.00000
Component Start Date (yyyy-mm-dd) 1995-01-01
Furnished Thickness (in) 0.3220000
Inspection Date (yyyy-mm-dd)
Measured Thickness (in)
Operating Temperature (°F) 269.0
Operating Pressure (psig) 875.0
Base Material
Corrosion Rate Estimated
Estimated Rate (mpy) 2
Measured Rate (mpy) 0.000
Gov Thinning Corrosion Rate (mpy) 0.0
Clad Material
Corrosion Rate Estimated
Estimated Rate (mpy) 0.000
Measured Rate (mpy) 0.000
Gov Thinning Corrosion Rate (mpy) 0.0
Calculated Results
Highest Effective Insp E
No Highest Effective Insp 0.000
Age (yrs) 11.3292265571526
DF 3.0000
Likelihood Category 2
Total DF 3.4456
POF 1.05435E-04
COF (ft²) 1.40692E+04
Risk Matrix 2E
Risk Category MEDIUM-HIGH
Maximum Risk 1.483392472938
Financial Risk ($/yr) 3661.234758665
Save
Help
Delete
Calculate
Comments

Circuit Summary

- System Summary – Feed line carrying Virgin Naphtha, Cracked Naphtha and Heavy Naphtha through preheat to first stage reactor
- Circuit Summary – Circuit 3 includes piping from first stage reactor feed (channel) to first stage reactor
- Material of Construction – Carbon Steel
- Estimated Corrosion Rate – 2 mpy
- Corrosion Type – General
- Primary Damage Mechanism – None
- Specific Location Concerns – None
- Deadlegs – 2 potential, created bypass line and closed valve during operation



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BPSD	2,800	12,200	15,000	–	–	–	–	–	–	–	–	–	–	–	–	–	–
MW	101	101	93	3.9	83.4	3.9	3.9	75.7	5.7	5.3	42.8	25	5.7	5.7	5.7	87.2	5.7
API	60.8	58.2	58.7	–	–	–	–	–	–	–	–	–	–	–	–	–	–

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BPSD	2,800	12,200	15,000	–	–	–	–	–	–	–	–	–	–	–	–	–	–
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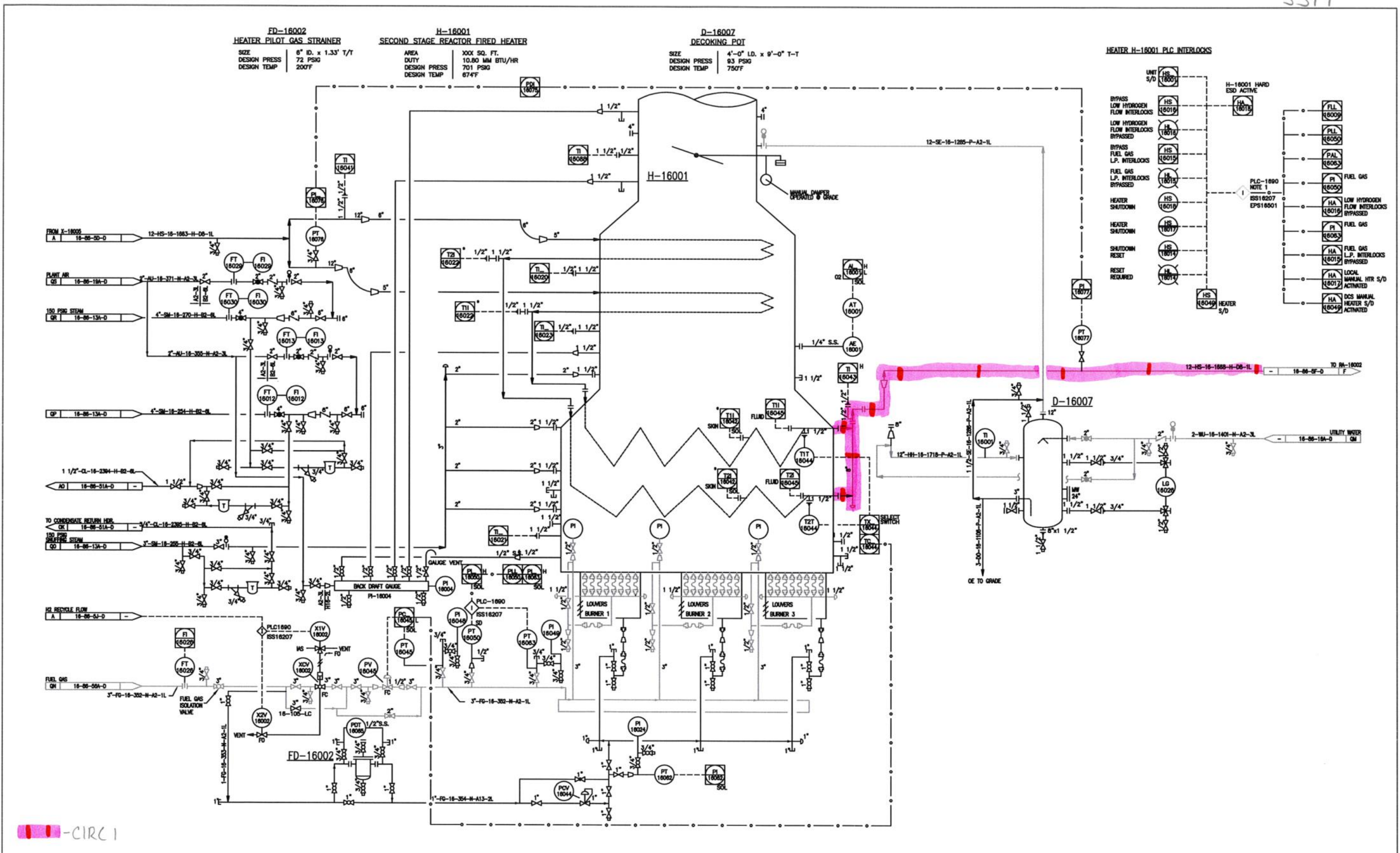
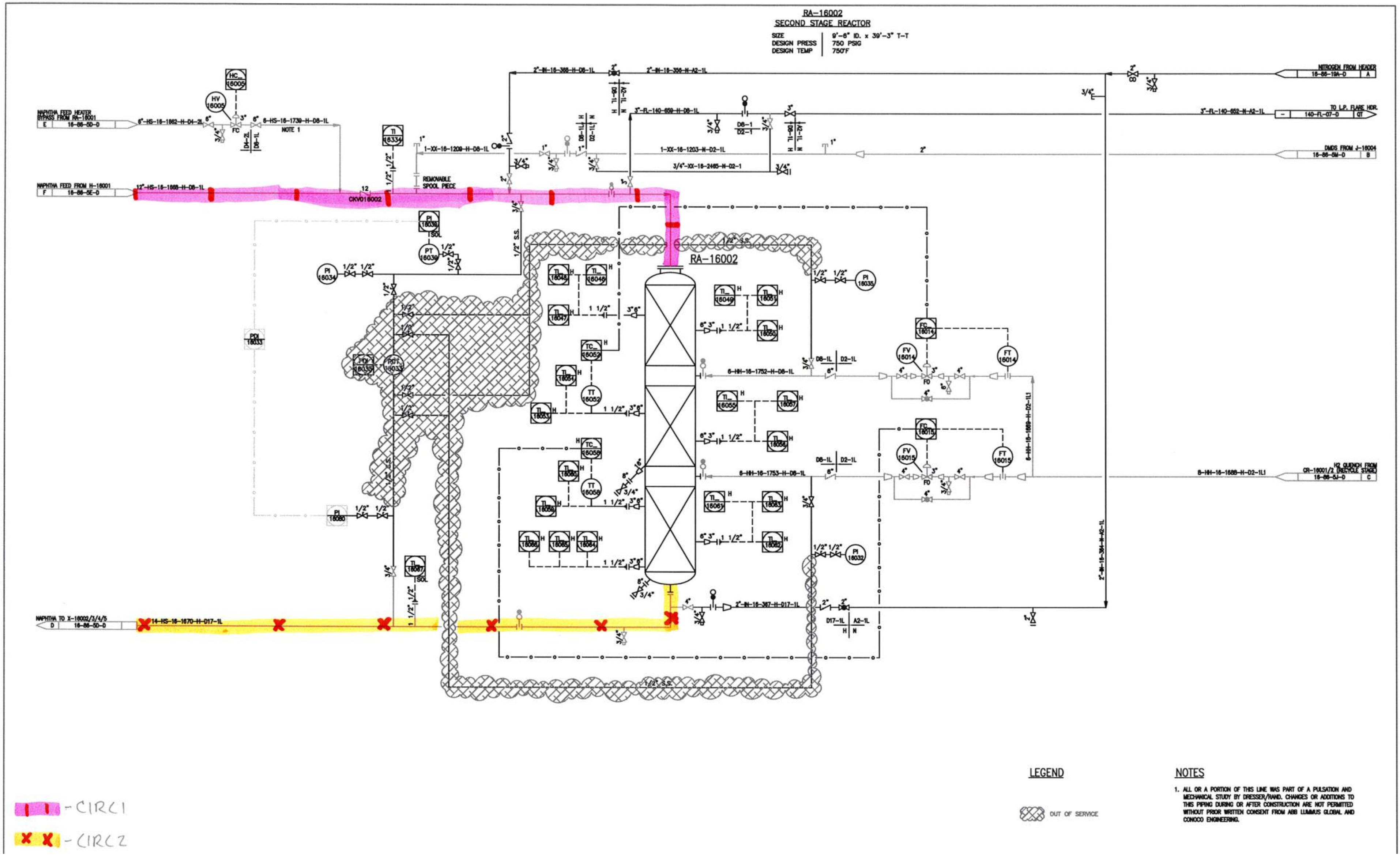
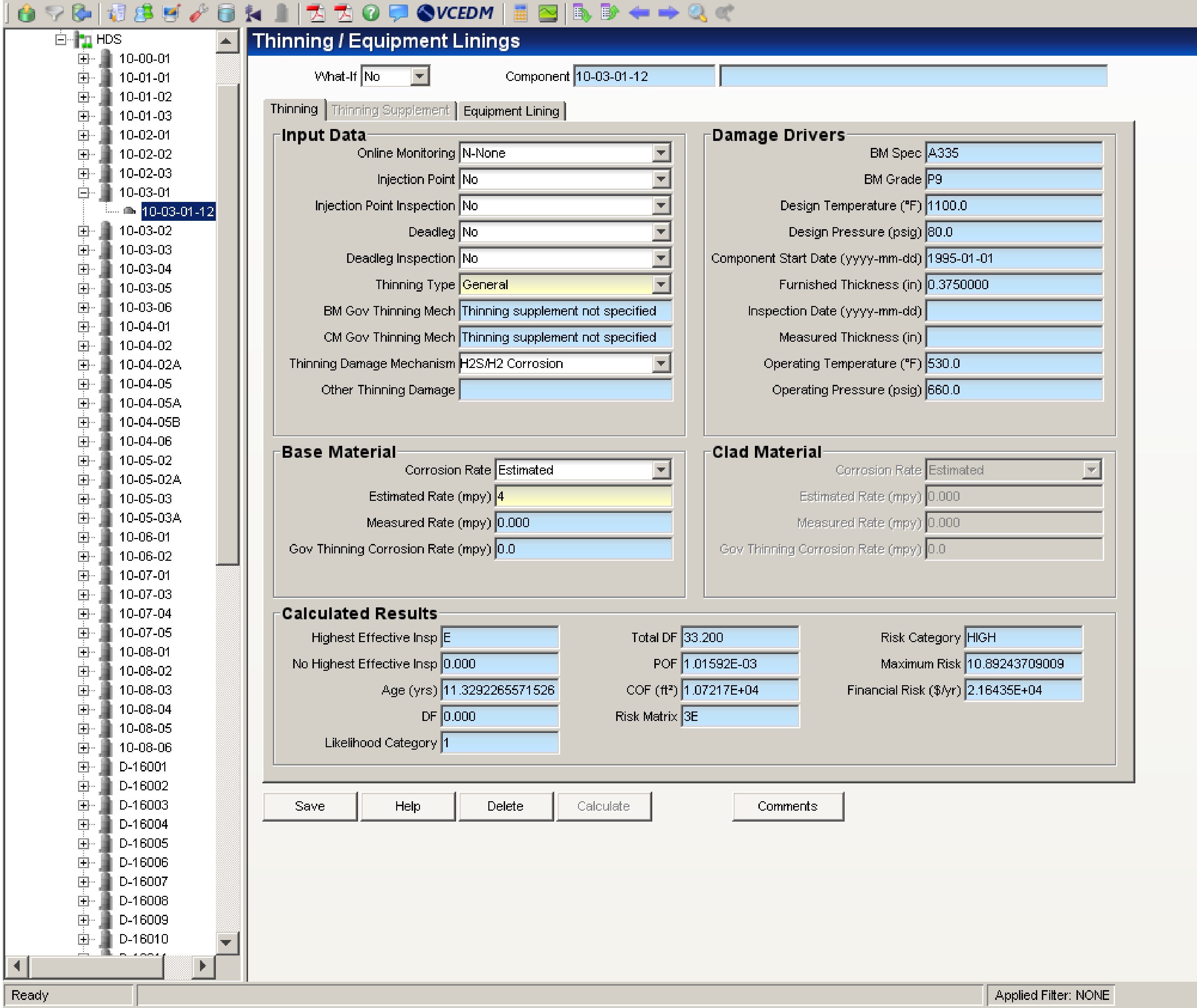
API	60.8	58.2	58.7	–	–	–	–	–	–	–	–	–	–	–	–	–	–


FD-16002
HEATER PILOT GAS STRAINER
H-16001
SECOND STAGE REACTOR FIRED HEATER
D-16007
DECOKING POT
HEATER H-16001 PLC INTERLOCKS
H-16001
D-16007
FD-16002
-CIRC 1

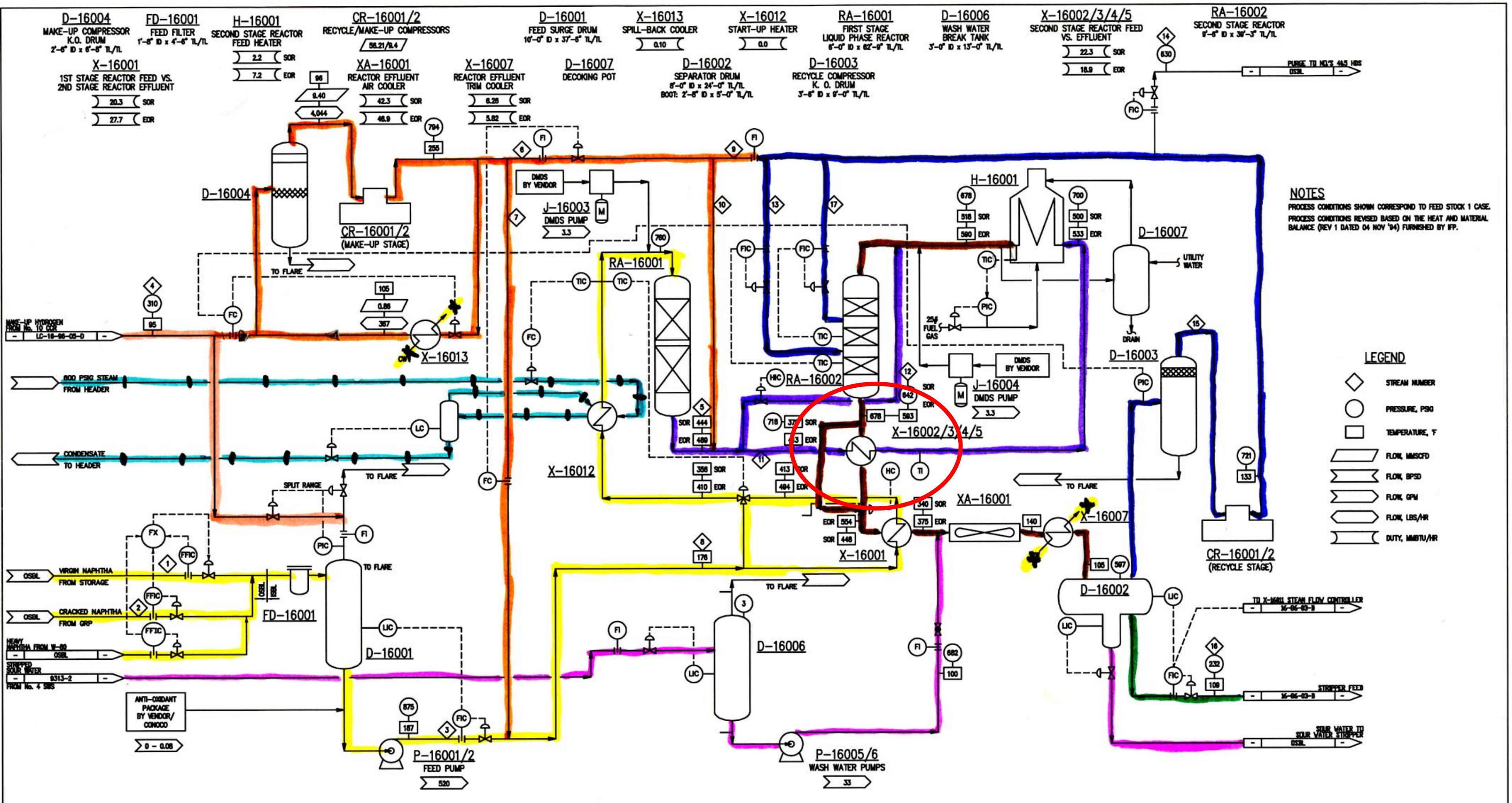

RA-16002
SECOND STAGE REACTOR
SIZE | 9'-6" ID. x 39'-3" T-T
DESIGN PRESS | 750 PSIG
DESIGN TEMP | 750°F
NITROGEN FROM HEADER
TO L.P. FLARE HDR.
DMDS FROM J-16004
NAPHTHA FEED HEATER BYPASS FROM RA-16001
NAPHTHA FEED FROM H-16001
NAPHTHA TO X-16002/3/4/5
H2 QUENCH FROM CR-16001/2 (RECYCLE STAGE)
REMOVABLE SPOOL PIECE
CKV016002
RA-16002
LEGEND
OUT OF SERVICE
NOTES
1. ALL OR A PORTION OF THIS LINE WAS PART OF A PULSATION AND MECHANICAL STUDY BY DRESSER/RAND. CHANGES OR ADDITIONS TO THIS PIPING DURING OR AFTER CONSTRUCTION ARE NOT PERMITTED WITHOUT PRIOR WRITTEN CONSENT FROM ABB LUMMUS GLOBAL AND CONOCO ENGINEERING.
- CIRC1
- CIRC2



Thinning / Equipment Linings
What-If No
Component 10-03-01-12
Thinning
Thinning Supplement
Equipment Lining
Input Data
Online Monitoring N-None
Injection Point No
Injection Point Inspection No
Deadleg No
Deadleg Inspection No
Thinning Type General
BM Gov Thinning Mech Thinning supplement not specified
CM Gov Thinning Mech Thinning supplement not specified
Thinning Damage Mechanism H2S/H2 Corrosion
Other Thinning Damage
Damage Drivers
BM Spec A335
BM Grade P9
Design Temperature (°F) 1100.0
Design Pressure (psig) 80.0
Component Start Date (yyyy-mm-dd) 1995-01-01
Furnished Thickness (in) 0.3750000
Inspection Date (yyyy-mm-dd)
Measured Thickness (in)
Operating Temperature (°F) 530.0
Operating Pressure (psig) 660.0
Base Material
Corrosion Rate Estimated
Estimated Rate (mpy) 4
Measured Rate (mpy) 0.000
Gov Thinning Corrosion Rate (mpy) 0.0
Clad Material
Corrosion Rate Estimated
Estimated Rate (mpy) 0.000
Measured Rate (mpy) 0.000
Gov Thinning Corrosion Rate (mpy) 0.0
Calculated Results
Highest Effective Insp E
No Highest Effective Insp 0.000
Age (yrs) 11.3292265571526
DF 0.000
Likelihood Category 1
Total DF 33.200
POF 1.01592E-03
COF (ft²) 1.07217E+04
Risk Matrix 3E
Risk Category HIGH
Maximum Risk 10.89243709009
Financial Risk ($/yr) 2.16435E+04
Save
Help
Delete
Calculate
Comments
HDS
10-00-01
10-01-01
10-01-02
10-01-03
10-02-01
10-02-02
10-02-03
10-03-01
10-03-01-12
10-03-02
10-03-03
10-03-04
10-03-05
10-03-06
10-04-01
10-04-02
10-04-02A
10-04-05
10-04-05A
10-04-05B
10-04-06
10-05-02
10-05-02A
10-05-03
10-05-03A
10-06-01
10-06-02
10-07-01
10-07-03
10-07-04
10-07-05
10-08-01
10-08-02
10-08-03
10-08-04
10-08-05
10-08-06
D-16001
D-16002
D-16003
D-16004
D-16005
D-16006
D-16007
D-16008
D-16009
D-16010
Ready
Applied Filter: NONE

Circuit Summary

- System Summary – Second Stage Reactor & Effluent
- Circuit Summary – Circuit 1 piping from the Second Stage Reactor Fired Heater to Second Stage Reactor
- Material of Construction – 9 Cr - ½ Mo
- Estimated Corrosion Rate – 4 mpy
- Corrosion Type – General
- Primary Damage Mechanism – H_2H_2S, HTHA (none)
- Specific Location Concerns – Straight run piping with potential high velocity conditions



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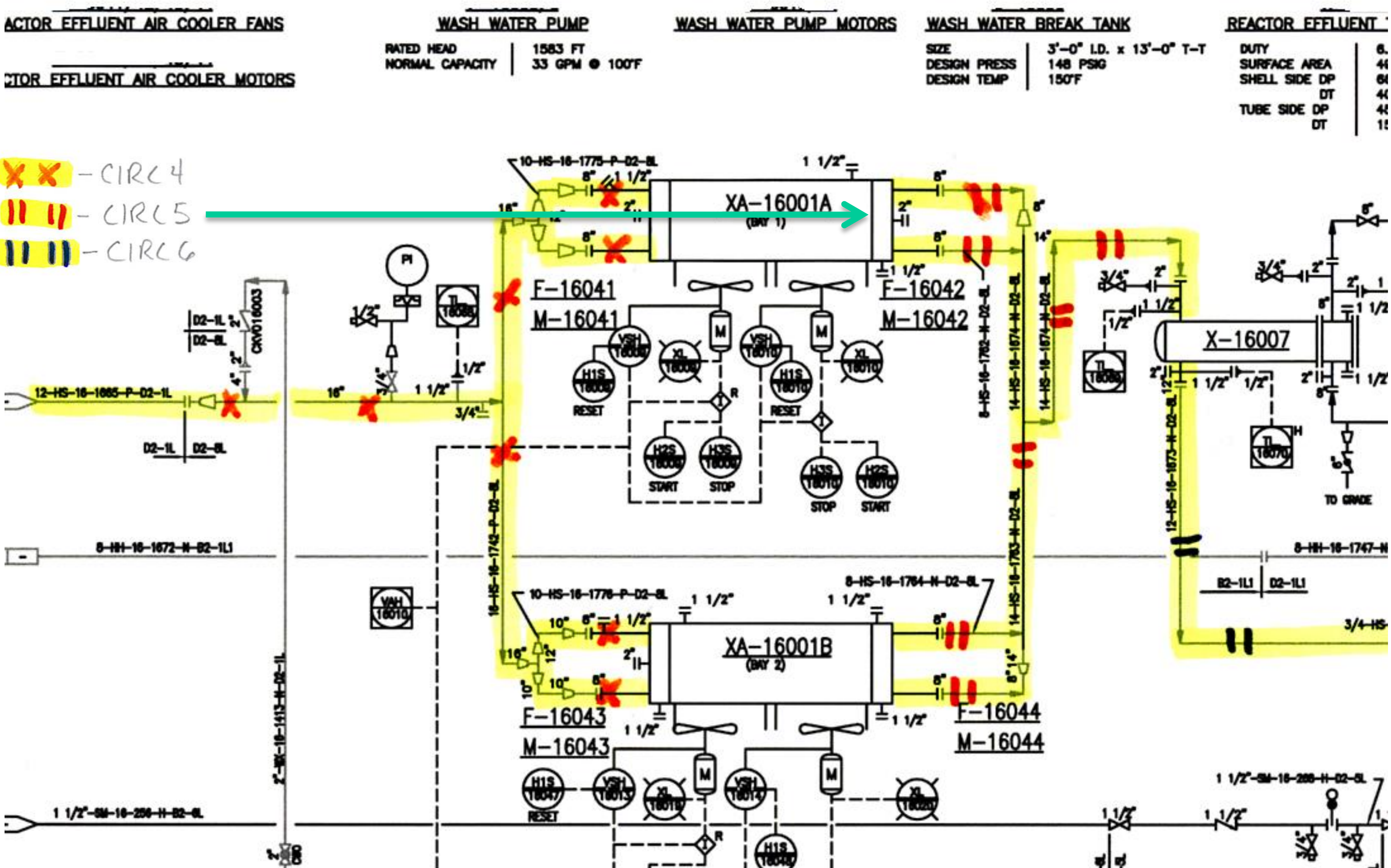
MW	101	101	93	3.9	83.4	3.9	3.9	75.7	5.7	5.3	42.8	25	5.7	5.7	5.7	87.2	5.7
API	60.8	58.2	58.7	–	–	–	–	–	–	–	–	–	–	–	–	–	–

FEED STOCK 1 END OF RUN

STREAM NO. / DESCRIPTION	1 NAPHTHA FROM STORAGE	2 NAPHTHA FROM GRP	3 COMBINED FEED	4 H_2 FROM REFORMER	5 REACTOR 1 OUTLET	6 H_2 MAKE-UP TO REACTOR 2	7 H_2 MAKE-UP TO REACTOR 1	8 X-16001 INLET	9 H_2 RECYCLE	10 MAKE-UP & RECYCLE H_2 TO RA-16002	11 X-16002/3/4/5 INLET	12 RA-16002 OUTLET	13 RA-16002 H_2 QUENCH	14 H_2 PURGE	15 RECYCLE COMPRESSOR INLET	16 STRIPPER FEED	17 RA-16002 H_2 QUENCH
LBS/HR	30,049	132,873	162,922	3,676	164,565	2,033	1,644	164,565	9,254	11,287	175,852	195,307	9,727	352	29,061	166,246	9,727
MMSCFD	–	–	–	8.53	–	4.72	3.82	–	14.73	19.45	–	63.62	15.56	0.56	46.23	–	15.56
BPSD	2,800	12,200	15,000	–	–	–	–	–	–	–	–	–	–	–	–	–	–
MW	101	101	93	3.9	83.4	3.9	3.9	75.7	5.7	5.3	42.8	28	5.7	5.7	5.7	87.2	5.7
API	60.8	58.2	58.7	–	–	–	–	–	–	–	–	–	–	–	–	–	–



ACTOR EFFLUENT AIR COOLER FANS
CTOR EFFLUENT AIR COOLER MOTORS
WASH WATER PUMP
RATED HEAD 1583 FT
NORMAL CAPACITY 33 GPM @ 100°F
WASH WATER PUMP MOTORS
WASH WATER BREAK TANK
SIZE 3'-0" I.D. x 13'-0" T-T
DESIGN PRESS 148 PSIG
DESIGN TEMP 150°F
REACTOR EFFLUENT
DUTY
SURFACE AREA
SHELL SIDE DP
DT
TUBE SIDE DP
DT
- CIRC 4
- CIRC 5
- CIRC 6
XA-16001A
(BAY 1)
XA-16001B
(BAY 2)
F-16041
M-16041
F-16042
M-16042
F-16043
M-16043
F-16044
M-16044
X-16007
10-HS-16-1775-P-D2-8L
10-HS-16-1776-P-D2-8L
8-HS-16-1764-N-D2-8L
12-HS-16-1665-P-D2-1L
8-HH-16-1672-N-B2-1L1
8-HH-16-1747-N
1 1/2"-SM-16-208-H-B2-6L
1 1/2"-SM-16-208-H-D2-6L
RESET
START
STOP
TO GRADE

Circuit Summary

- System Summary – Second Stage Reactor & Effluent
- Circuit Summary – Circuit 5 Piping from the Reactor Effluent Air Coolers to the Shell Side of Reactor Effluent Trim Cooler
- Estimated Corrosion Rate – 7 mpy
- Corrosion Type – Local
- Primary Damage Mechanism – Ammonium Bisulfide/Chlorides
- Specific Location Concerns – Elbows, high velocity areas (>20 ft/sec)

Piping Risk Analysis Summary

- HDS Unit with 8 PFD, 67 P&ID's and 1,670 lines in the line list provided for the study:
  - Develop corrosion systems and circuits with common damage mechanisms and expected corrosion rates for the main hydrocarbon containing lines and branch connections (utilities services, drain lines, flare lines were excluded).
  - Integrate the new defined corrosion circuits with existing RBI file (naming conventions, re-grouping at the circuit level).
  - Estimate the corrosion rate on a circuit basis and add to the RBI file.
  - Add all necessary mechanical and operating data for each piping circuit in the existing RBI files and recalculate the risk/inspection plans for this Unit.
  - Develop color coded piping System and Circuit drawings utilizing the PFD's and P&ID's.

HDS Summary

- 23 Systems
- 146 Circuits
- 27 circuits (~18%) which potentially problems due to:
  - Material of construction at the current operating conditions
  - Piping design (location of check valves, specification break, etc.)
- Potential problems due to corrosion in H_2S, Chlorides, Ammonia bisulfide, Ammonia Chlorides environments; High Temperature service (creep); Corrosion Under Insulation (CUI)

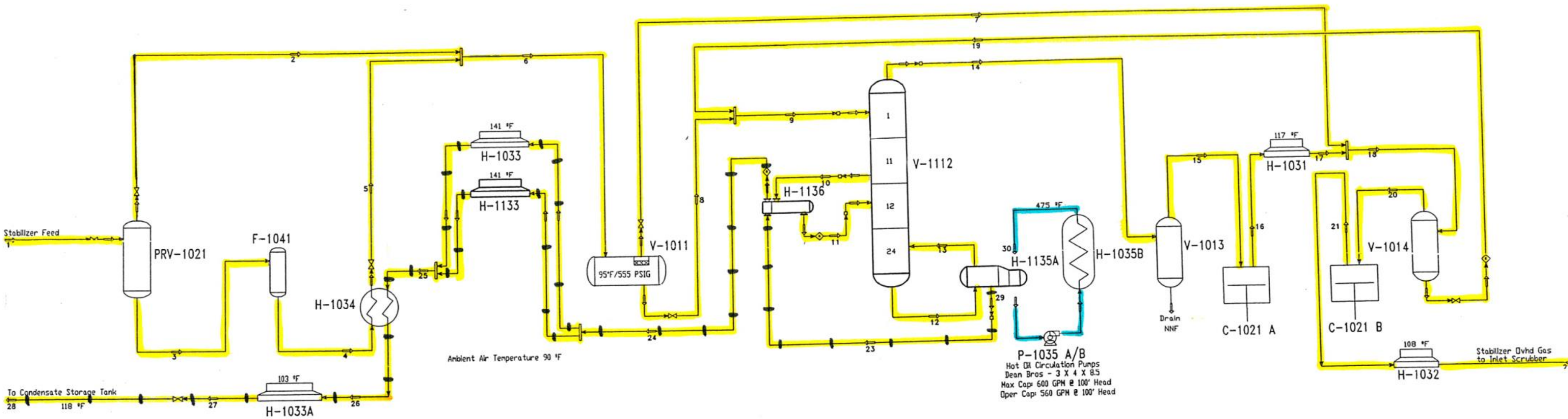
Example 2

Gas Plant

System Key – Gas Plant

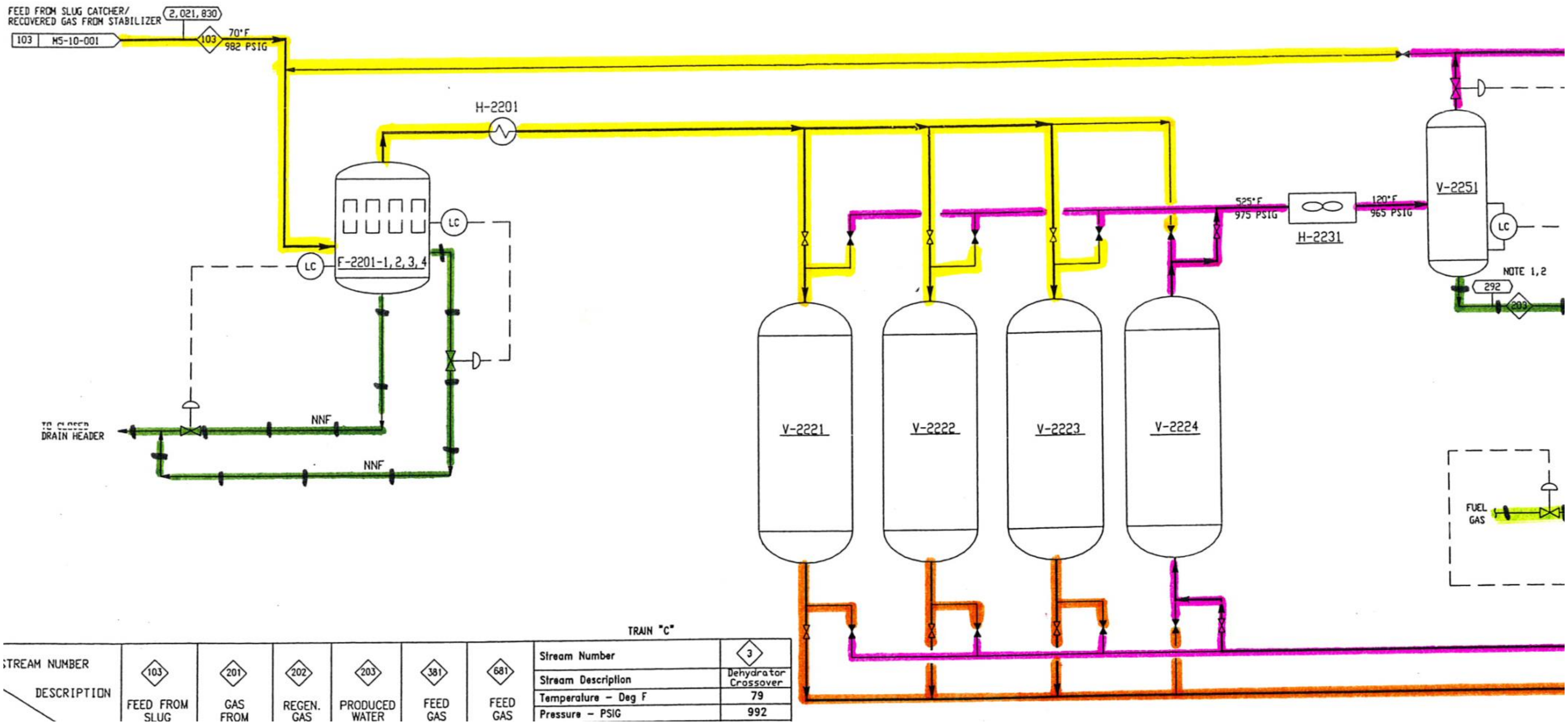
Process Stream	Identifier	Color Code
RAW FEED	FD	
STABILIZED FEED CONDENSATE	STAB	
COMPRESSION	COMP	
DEHYDRATION 1	DEHY1	
DEHYDRATION 2	DEHY2	
CRYOGENICS TRAIN A	CRYOA	
CRYOGENICS TRAIN B	CRYOB	
DEMETHANIZER BOTTOMS TRAIN A	DMBA	
DEMETHANIZER OVERHEADS TRAIN A	DMOA	
DEMETHANIZER BOTTOMS TRAIN B	DMBB	
DEMETHANIZER OVERHEADS TRAIN B	DMOB	
REGENERATION	REGEN	
REFRIGERATION	RFG	
LUBE OIL	LBOIL	
FUEL GAS	FLG	
HEAT MEDIUM	HTOIL	
FLARE	FLR	
DRAIN	DRN	

Feed System



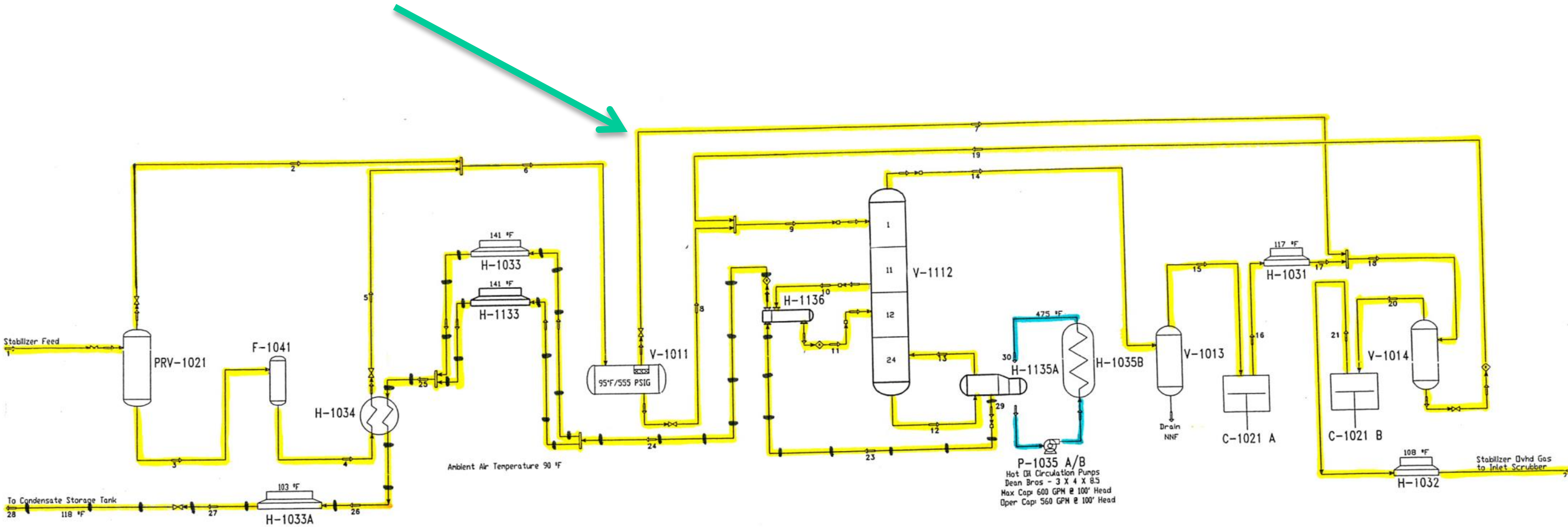
Stabilizer Feed
PRV-1021
F-1041
H-1034
H-1033
141 °F
H-1133
141 °F
V-1011
95°F/555 PSIG
Ambient Air Temperature 90 °F
To Condensate Storage Tank
118 °F
103 °F
H-1033A
H-1136
V-1112
475 °F
H-1135A
H-1035B
P-1035 A/B
Hot Oil Circulation Pumps
Dean Bros - 3 X 4 X 8.5
Max Cap: 600 GPM @ 100' Head
Oper Cap: 560 GPM @ 100' Head
V-1013
Drain
NNF
C-1021 A
117 °F
H-1031
C-1021 B
V-1014
108 °F
H-1032
Stabilizer Ovhd Gas
to Inlet Scrubber

Feed System

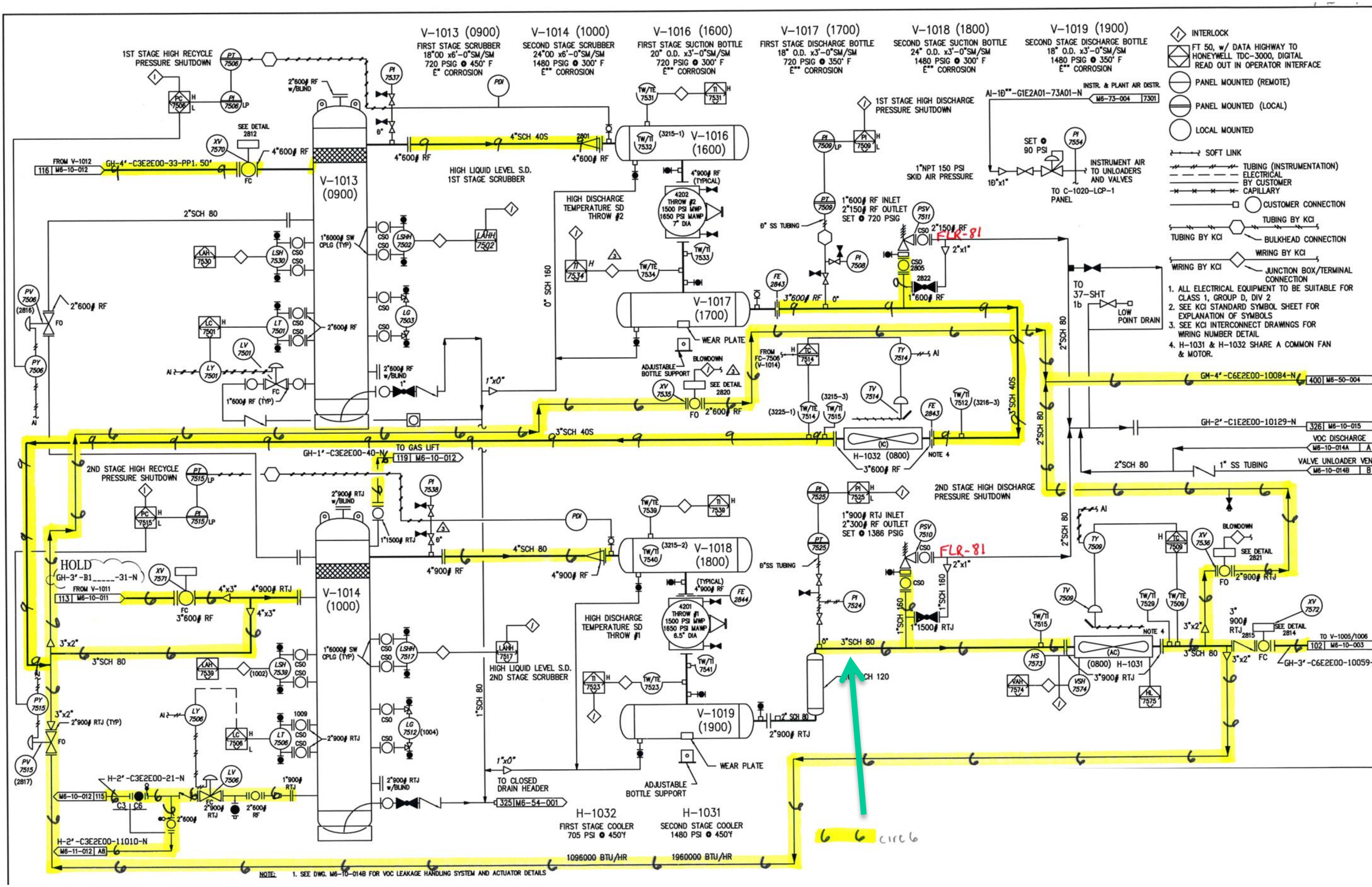


FEED FROM SLUG CATCHER/
RECOVERED GAS FROM STABILIZER
2,021,830
103
MS-10-001
70°F
982 PSIG
H-2201
LC
F-2201-1,2,3,4
NNF
TO CLOSED DRAIN HEADER
525°F
975 PSIG
H-2231
120°F
965 PSIG
V-2251
NOTE 1,2
292
203
V-2221
V-2222
V-2223
V-2224
FUEL GAS
TRAIN "C"
STREAM NUMBER
DESCRIPTION
103 FEED FROM SLUG
201 GAS FROM
202 REGEN. GAS
203 PRODUCED WATER
381 FEED GAS
681 FEED GAS
Stream Number 3
Stream Description Dehydrator Crossover
Temperature - Deg F 79
Pressure - PSIG 992

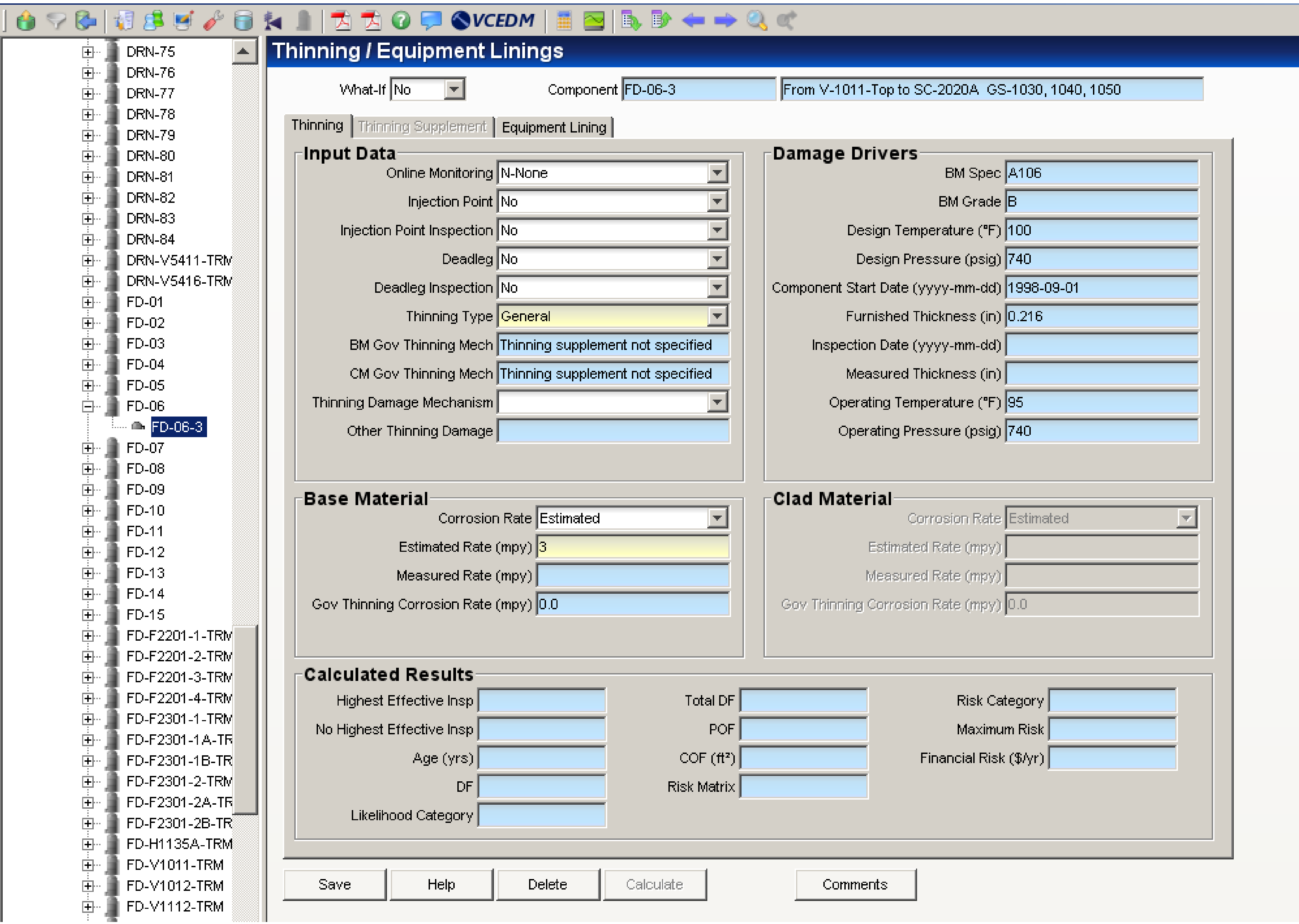
Feed System



Stabilizer Feed
PRV-1021
F-1041
H-1034
H-1033
141 °F
H-1133
H-1033A
103 °F
To Condensate Storage Tank
118 °F
Ambient Air Temperature 90 °F
V-1011
95°F/555 PSIG
H-1136
V-1112
H-1135A
H-1035B
475 °F
P-1035 A/B
Hot Oil Circulation Pumps
Dean Bros - 3 X 4 X 8.5
Max Cap: 600 GPM @ 100' Head
Oper Cap: 560 GPM @ 100' Head
V-1013
Drain
NNF
C-1021 A
H-1031
117 °F
C-1021 B
V-1014
H-1032
108 °F
Stabilizer Ovhd Gas to Inlet Scrubber



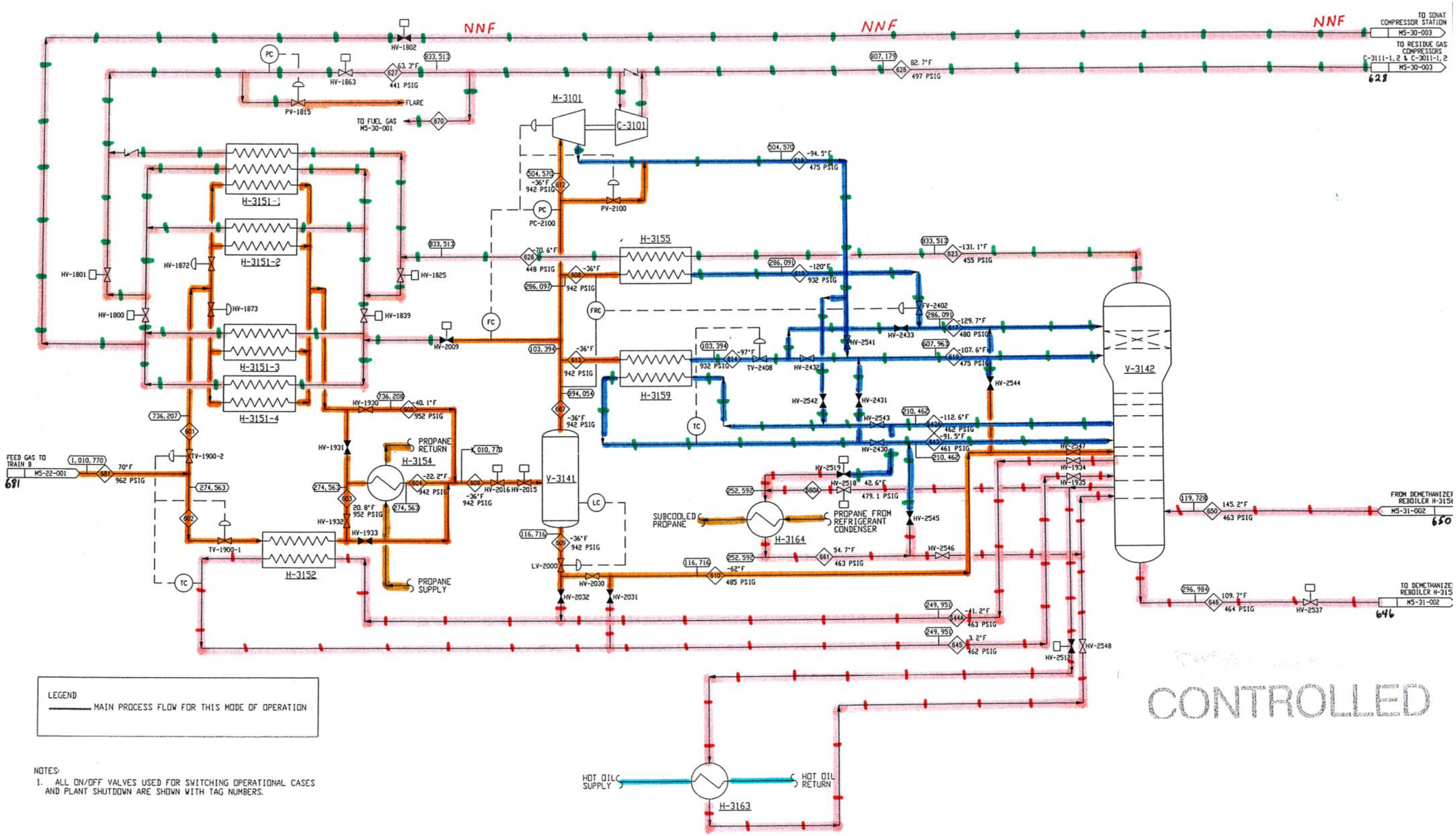
V-1013 (0900)
FIRST STAGE SCRUBBER
18"OD x6'-0"SM/SM
720 PSIG @ 450° F
E"" CORROSION
V-1014 (1000)
SECOND STAGE SCRUBBER
24"OD x6'-0"SM/SM
1480 PSIG @ 300° F
E"" CORROSION
V-1016 (1600)
FIRST STAGE SUCTION BOTTLE
20" O.D. x3'-0"SM/SM
720 PSIG @ 300° F
E"" CORROSION
V-1017 (1700)
FIRST STAGE DISCHARGE BOTTLE
18" O.D. x3'-0"SM/SM
720 PSIG @ 350° F
E"" CORROSION
V-1018 (1800)
SECOND STAGE SUCTION BOTTLE
24" O.D. x3'-0"SM/SM
1480 PSIG @ 300° F
E"" CORROSION
V-1019 (1900)
SECOND STAGE DISCHARGE BOTTLE
18" O.D. x3'-0"SM/SM
1480 PSIG @ 350° F
E"" CORROSION
INTERLOCK
FT 50, w/ DATA HIGHWAY TO HONEYWELL TDC-3000, DIGITAL READ OUT IN OPERATOR INTERFACE
PANEL MOUNTED (REMOTE)
PANEL MOUNTED (LOCAL)
LOCAL MOUNTED
SOFT LINK
TUBING (INSTRUMENTATION)
ELECTRICAL
BY CUSTOMER
CAPILLARY
CUSTOMER CONNECTION
TUBING BY KCI
BULKHEAD CONNECTION
WIRING BY KCI
JUNCTION BOX/TERMINAL CONNECTION
1. ALL ELECTRICAL EQUIPMENT TO BE SUITABLE FOR CLASS 1, GROUP D, DIV 2
2. SEE KCI STANDARD SYMBOL SHEET FOR EXPLANATION OF SYMBOLS
3. SEE KCI INTERCONNECT DRAWINGS FOR WIRING NUMBER DETAIL
4. H-1031 & H-1032 SHARE A COMMON FAN & MOTOR.
1ST STAGE HIGH RECYCLE PRESSURE SHUTDOWN
1ST STAGE HIGH DISCHARGE PRESSURE SHUTDOWN
2ND STAGE HIGH RECYCLE PRESSURE SHUTDOWN
2ND STAGE HIGH DISCHARGE PRESSURE SHUTDOWN
HIGH LIQUID LEVEL S.D. 1ST STAGE SCRUBBER
HIGH LIQUID LEVEL S.D. 2ND STAGE SCRUBBER
HIGH DISCHARGE TEMPERATURE SD THROW #2
HIGH DISCHARGE TEMPERATURE SD THROW #1
FROM V-1012
GH-4"-C3E2E00-33-PP1. 50'
FROM V-1011
GH-3"-B1_____-31-N
HOLD
GH-4"-C6E2E00-10084-N
GH-2"-C1E2E00-10129-N
GH-3"-C6E2E00-10059-N
GH-1"-C3E2E00-40-N
TO GAS LIFT
H-2"-C3E2E00-21-N
H-2"-C3E2E00-11010-N
INSTRUMENT AIR TO UNLOADERS AND VALVES
TO C-1020-LCP-1 PANEL
1"NPT 150 PSI SKID AIR PRESSURE
VOC DISCHARGE
VALVE UNLOADER VENT
LOW POINT DRAIN
TO 37-SHT 1b
TO V-1005/1006
TO CLOSED DRAIN HEADER
WEAR PLATE
ADJUSTABLE BOTTLE SUPPORT
BLOWDOWN
FLR-81
H-1032 (0800)
H-1031 (0800)
H-1032
FIRST STAGE COOLER
705 PSI @ 450°f
1096000 BTU/HR
H-1031
SECOND STAGE COOLER
1480 PSI @ 450°f
1960000 BTU/HR
NOTE: 1. SEE DWG. M6-10-014B FOR VOC LEAKAGE HANDLING SYSTEM AND ACTUATOR DETAILS
circ6

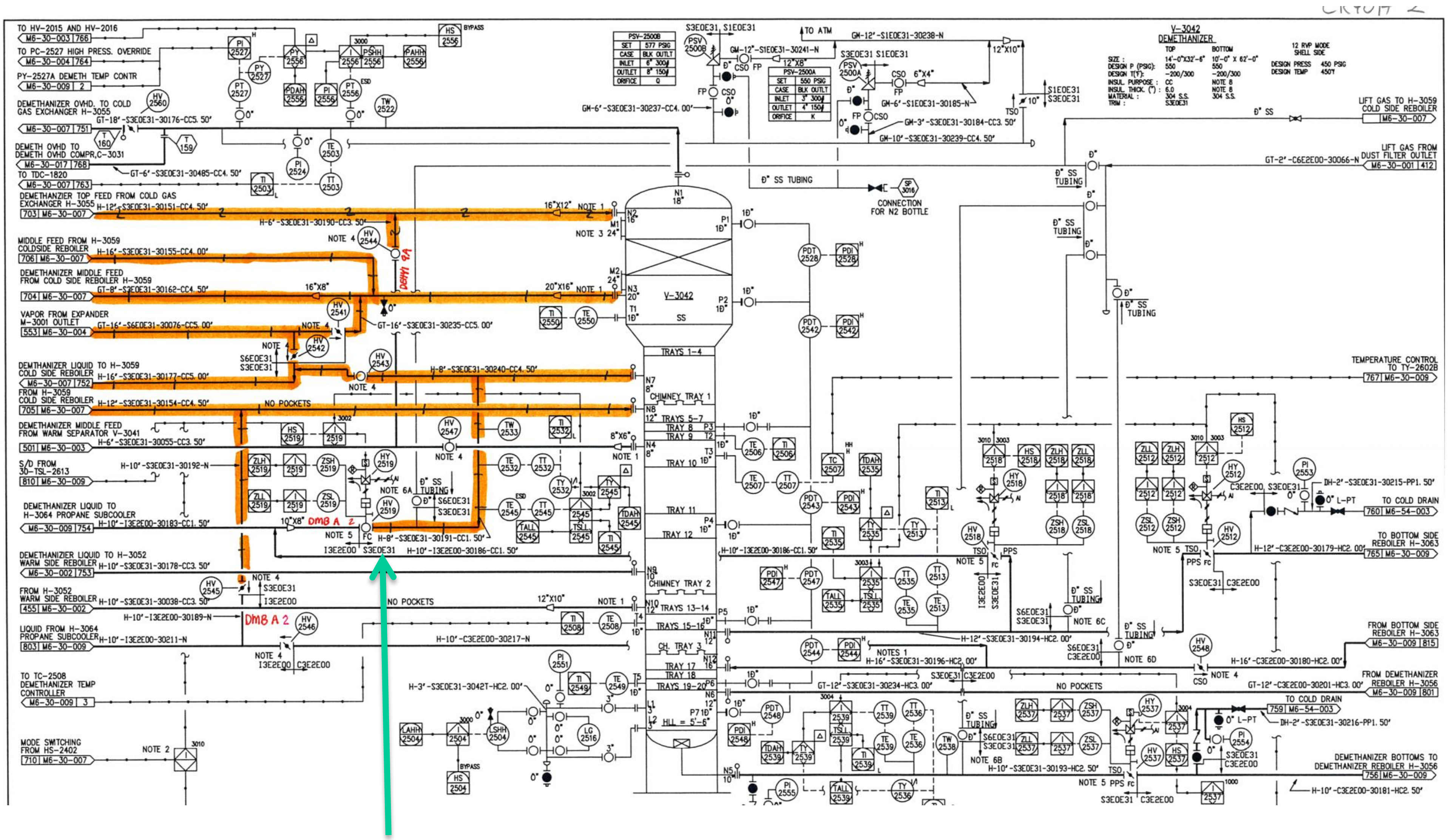

VCEDM
DRN-75
DRN-76
DRN-77
DRN-78
DRN-79
DRN-80
DRN-81
DRN-82
DRN-83
DRN-84
DRN-V5411-TRM
DRN-V5416-TRM
FD-01
FD-02
FD-03
FD-04
FD-05
FD-06
FD-06-3
FD-07
FD-08
FD-09
FD-10
FD-11
FD-12
FD-13
FD-14
FD-15
FD-F2201-1-TRM
FD-F2201-2-TRM
FD-F2201-3-TRM
FD-F2201-4-TRM
FD-F2301-1-TRM
FD-F2301-1A-TR
FD-F2301-1B-TR
FD-F2301-2-TRM
FD-F2301-2A-TR
FD-F2301-2B-TR
FD-H1135A-TRM
FD-V1011-TRM
FD-V1012-TRM
FD-V1112-TRM
Thinning / Equipment Linings
What-If No
Component FD-06-3
From V-1011-Top to SC-2020A GS-1030, 1040, 1050
Thinning
Thinning Supplement
Equipment Lining
Input Data
Online Monitoring N-None
Injection Point No
Injection Point Inspection No
Deadleg No
Deadleg Inspection No
Thinning Type General
BM Gov Thinning Mech Thinning supplement not specified
CM Gov Thinning Mech Thinning supplement not specified
Thinning Damage Mechanism
Other Thinning Damage
Damage Drivers
BM Spec A106
BM Grade B
Design Temperature (°F) 100
Design Pressure (psig) 740
Component Start Date (yyyy-mm-dd) 1998-09-01
Furnished Thickness (in) 0.216
Inspection Date (yyyy-mm-dd)
Measured Thickness (in)
Operating Temperature (°F) 95
Operating Pressure (psig) 740
Base Material
Corrosion Rate Estimated
Estimated Rate (mpy) 3
Measured Rate (mpy)
Gov Thinning Corrosion Rate (mpy) 0.0
Clad Material
Corrosion Rate Estimated
Estimated Rate (mpy)
Measured Rate (mpy)
Gov Thinning Corrosion Rate (mpy) 0.0
Calculated Results
Highest Effective Insp
No Highest Effective Insp
Age (yrs)
DF
Likelihood Category
Total DF
POF
COF (ft²)
Risk Matrix
Risk Category
Maximum Risk
Financial Risk ($/yr)
Save
Help
Delete
Calculate
Comments

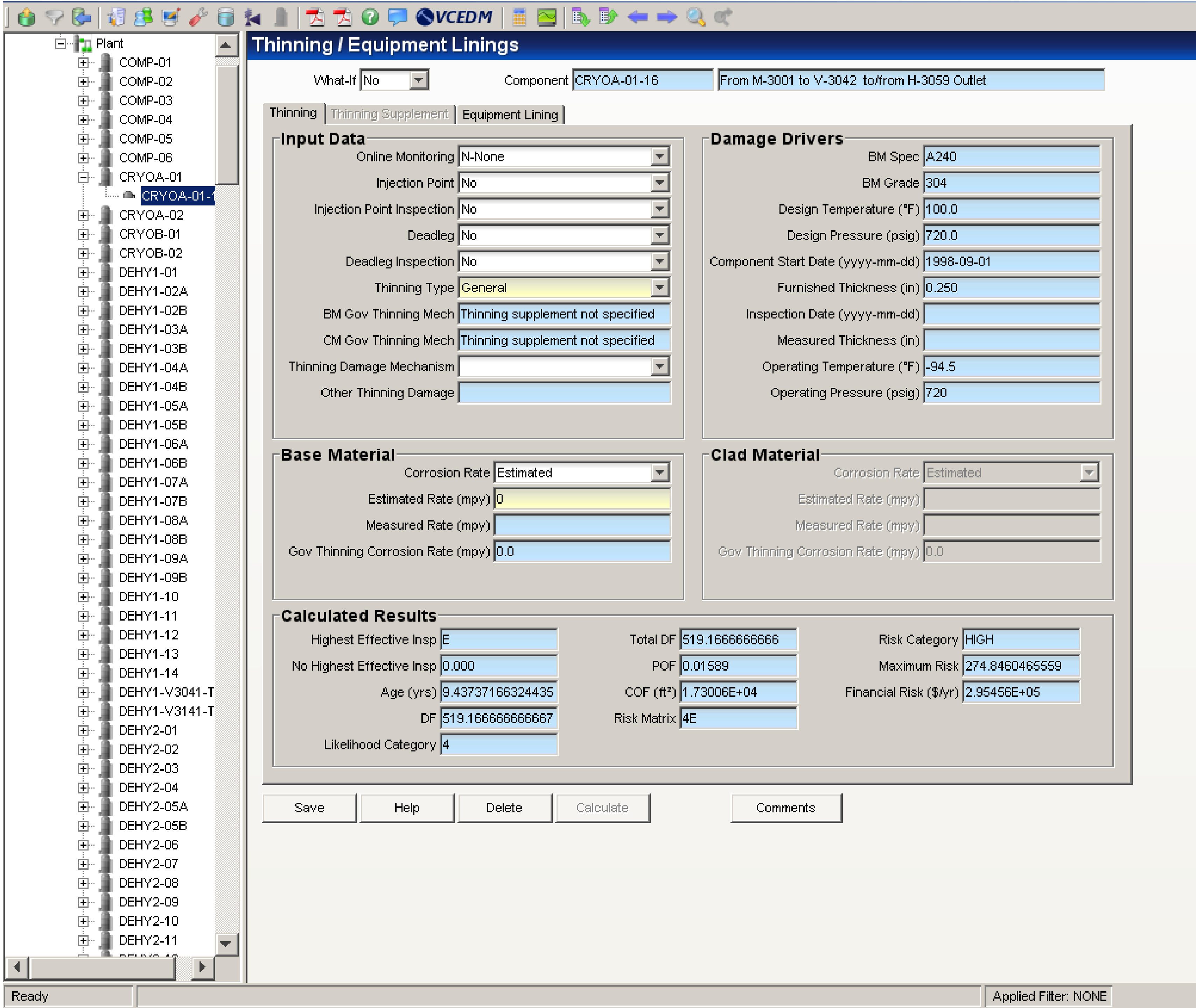
Circuit Summary

- System Summary – Feed line from offshore platforms to Dehydration system
- Circuit Summary – Circuit 6 includes piping from the Stabilizer Feed Drum top to the Stabilizer Overhead Compressor Skid
- Material of Construction – Carbon Steel
- Estimated Corrosion Rate (internal) – 3 mpy
- Corrosion Type – General
- External Corrosion Rate – 2.9 mpy
- Primary Damage Mechanism – CUI
- Specific Location Concerns
  - Internal corrosion - low points and deadlegs, areas where water collects
  - Damaged insulation or weatherproofing
- Deadlegs – 3 potential

Cryogenic System




V-3042
DEMETHANIZER
TO HV-2015 AND HV-2016
M6-30-003 766
TO PC-2527 HIGH PRESS. OVERRIDE
M6-30-004 764
PY-2527A DEMETH TEMP CONTR
M6-30-009 2
DEMETHANIZER OVHD. TO COLD GAS EXCHANGER H-3055
GT-18"-S3E0E31-30176-CC5. 50'
M6-30-007 751
DEMETH OVHD TO DEMETH OVHD COMPR, C-3031
M6-30-017 768
TO TDC-1820
M6-30-007 763
GT-6"-S3E0E31-30485-CC4. 50'
DEMETHANZIER TOP FEED FROM COLD GAS EXCHANGER H-3055
H-12"-S3E0E31-30151-CC4. 50'
703 M6-30-007
H-6"-S3E0E31-30190-CC3. 50'
MIDDLE FEED FROM H-3059 COLDSIDE REBOILER
H-16"-S3E0E31-30155-CC4. 00'
706 M6-30-007
DEMETHANIZER MIDDLE FEED FROM COLD SIDE REBOILER H-3059
GT-8"-S3E0E31-30162-CC4. 50'
704 M6-30-007
VAPOR FROM EXPANDER M-3001 OUTLET
GT-16"-S6E0E31-30076-CC5. 00'
553 M6-30-004
GT-16"-S3E0E31-30235-CC5. 00'
DEHY 9A
DEMTHANIZER LIQUID TO H-3059 COLD SIDE REBOILER
H-16"-S3E0E31-30177-CC5. 00'
M6-30-007 752
FROM H-3059 COLD SIDE REBOILER
H-12"-S3E0E31-30154-CC4. 50'
705 M6-30-007
NO POCKETS
H-8"-S3E0E31-30240-CC4. 50'
DEMETHANIZER MIDDLE FEED FROM WARM SEPARATOR V-3041
H-6"-S3E0E31-30055-CC3. 50'
501 M6-30-003
S/D FROM 30-TSL-2613
H-10"-S3E0E31-30192-N
810 M6-30-009
DEMETHANIZER LIQUID TO H-3064 PROPANE SUBCOOLER
H-10"-I3E2E00-30183-CC1. 50'
M6-30-009 754
DMB A 2
H-8"-S3E0E31-30191-CC1. 50'
I3E2E00 S3E0E31
H-10"-I3E2E00-30186-CC1. 50'
DEMETHANIZER LIQUID TO H-3052 WARM SIDE REBOILER
H-10"-S3E0E31-30178-CC3. 50'
M6-30-002 753
FROM H-3052 WARM SIDE REBOILER
H-10"-S3E0E31-30038-CC3. 50'
455 M6-30-002
H-10"-I3E2E00-30189-N
DMB A 2
LIQUID FROM H-3064 PROPANE SUBCOOLER
H-10"-I3E2E00-30211-N
803 M6-30-009
H-10"-C3E2E00-30217-N
TO TC-2508 DEMETHANIZER TEMP CONTROLLER
M6-30-009 3
MODE SWITCHING FROM HS-2402
710 M6-30-007
H-3"-S3E0E31-3042T-HC2. 00'
PSV-2500B
PSV-2500A
GM-12"-S1E0E31-30241-N
GM-6"-S3E0E31-30237-CC4. 00'
GM-12"-S1E0E31-30238-N
GM-6"-S1E0E31-30185-N
GM-3"-S3E0E31-30184-CC3. 50'
GM-10"-S3E0E31-30239-CC4. 50'
TO ATM
CONNECTION FOR N2 BOTTLE
LIFT GAS TO H-3059 COLD SIDE REBOILER
M6-30-007
LIFT GAS FROM DUST FILTER OUTLET
GT-2"-C6E2E00-30066-N
M6-30-001 412
TEMPERATURE CONTROL TO TY-2602B
767 M6-30-009
DH-2"-S3E0E31-30215-PP1. 50'
TO COLD DRAIN
760 M6-54-003
TO BOTTOM SIDE REBOILER H-3063
H-12"-C3E2E00-30179-HC2. 00'
765 M6-30-009
H-10"-I3E2E00-30186-CC1. 50'
H-12"-S3E0E31-30194-HC2. 00'
H-16"-S3E0E31-30196-HC2. 00'
FROM BOTTOM SIDE REBOILER H-3063
H-16"-C3E2E00-30180-HC2. 00'
M6-30-009 815
FROM DEMETHANIZER REBOILER H-3056
GT-12"-C3E2E00-30201-HC3. 00'
M6-30-009 801
GT-12"-S3E0E31-30234-HC3. 00'
NO POCKETS
TO COLD DRAIN
759 M6-54-003
DH-2"-S3E0E31-30216-PP1. 50'
DEMETHANIZER BOTTOMS TO DEMETHANIZER REBOILER H-3056
756 M6-30-009
H-10"-S3E0E31-30193-HC2. 50'
H-10"-C3E2E00-30181-HC2. 50'
CHIMNEY TRAY 1
TRAYS 1-4
TRAYS 5-7
TRAY 8
TRAY 9
TRAY 10
TRAY 11
TRAY 12
CHIMNEY TRAY 2
TRAYS 13-14
TRAYS 15-16
CH. TRAY 3
TRAY 17
TRAY 18
TRAYS 19-20
HLL = 5'-6"


VCEDM
Plant
COMP-01
COMP-02
COMP-03
COMP-04
COMP-05
COMP-06
CRYOA-01
CRYOA-01-1
CRYOA-02
CRYOB-01
CRYOB-02
DEHY1-01
DEHY1-02A
DEHY1-02B
DEHY1-03A
DEHY1-03B
DEHY1-04A
DEHY1-04B
DEHY1-05A
DEHY1-05B
DEHY1-06A
DEHY1-06B
DEHY1-07A
DEHY1-07B
DEHY1-08A
DEHY1-08B
DEHY1-09A
DEHY1-09B
DEHY1-10
DEHY1-11
DEHY1-12
DEHY1-13
DEHY1-14
DEHY1-V3041-T
DEHY1-V3141-T
DEHY2-01
DEHY2-02
DEHY2-03
DEHY2-04
DEHY2-05A
DEHY2-05B
DEHY2-06
DEHY2-07
DEHY2-08
DEHY2-09
DEHY2-10
DEHY2-11
Thinning / Equipment Linings
What-If No
Component CRYOA-01-16
From M-3001 to V-3042 to/from H-3059 Outlet
Thinning
Thinning Supplement
Equipment Lining
Input Data
Online Monitoring N-None
Injection Point No
Injection Point Inspection No
Deadleg No
Deadleg Inspection No
Thinning Type General
BM Gov Thinning Mech Thinning supplement not specified
CM Gov Thinning Mech Thinning supplement not specified
Thinning Damage Mechanism
Other Thinning Damage
Damage Drivers
BM Spec A240
BM Grade 304
Design Temperature (°F) 100.0
Design Pressure (psig) 720.0
Component Start Date (yyyy-mm-dd) 1998-09-01
Furnished Thickness (in) 0.250
Inspection Date (yyyy-mm-dd)
Measured Thickness (in)
Operating Temperature (°F) -94.5
Operating Pressure (psig) 720
Base Material
Corrosion Rate Estimated
Estimated Rate (mpy) 0
Measured Rate (mpy)
Gov Thinning Corrosion Rate (mpy) 0.0
Clad Material
Corrosion Rate Estimated
Estimated Rate (mpy)
Measured Rate (mpy)
Gov Thinning Corrosion Rate (mpy) 0.0
Calculated Results
Highest Effective Insp E
No Highest Effective Insp 0.000
Age (yrs) 9.43737166324435
DF 519.166666666667
Likelihood Category 4
Total DF 519.1666666666
POF 0.01589
COF (ft²) 1.73006E+04
Risk Matrix 4E
Risk Category HIGH
Maximum Risk 274.8460465559
Financial Risk ($/yr) 2.95456E+05
Save
Help
Delete
Calculate
Comments
Ready
Applied Filter: NONE

Circuit Summary

- System Summary – Piping from the Expander to Demethanizer Column and from the Cold Gas/Gas Exchangers; MeOH injection point in this system
- Circuit Summary – Circuit 1 includes piping from the Expander to the Demethanizer and to/from the Cold Side Reboiler
- Material of Construction – Stainless Steel
- Estimated Corrosion Rate (internal) – 0 mpy
- Corrosion Type – General
- External Corrosion Susceptibility – None
- Primary Damage Mechanism – CUI Austenitic Stainless Steels
- Specific Location Concerns – Possible CUI concerns at interface of insulated equipment and un-insulated protrusions
- 7 potential Deadlegs; 1 potential injection/mix point

Gas Plant Summary

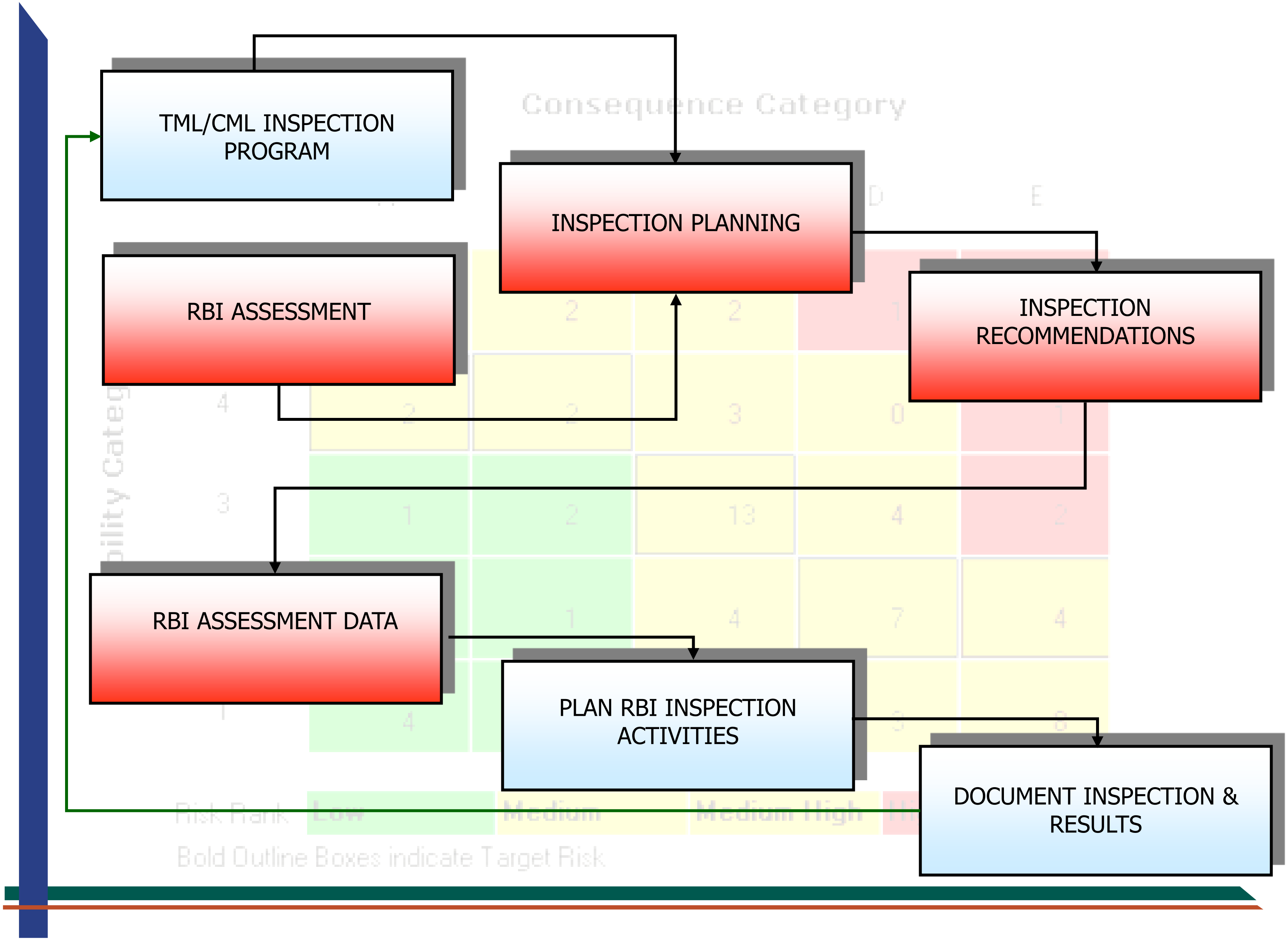
- 18 Systems
- 344 Circuits
- 28 circuits (~8%) with potential internal corrosion in aqueous conditions
- Potential problems due to aqueous corrosion due to low levels of H_2S and water
- Corrosion Under Insulation (CUI) in marine environment and in Gulf coastline (hurricane) affects potentially 75% of piping

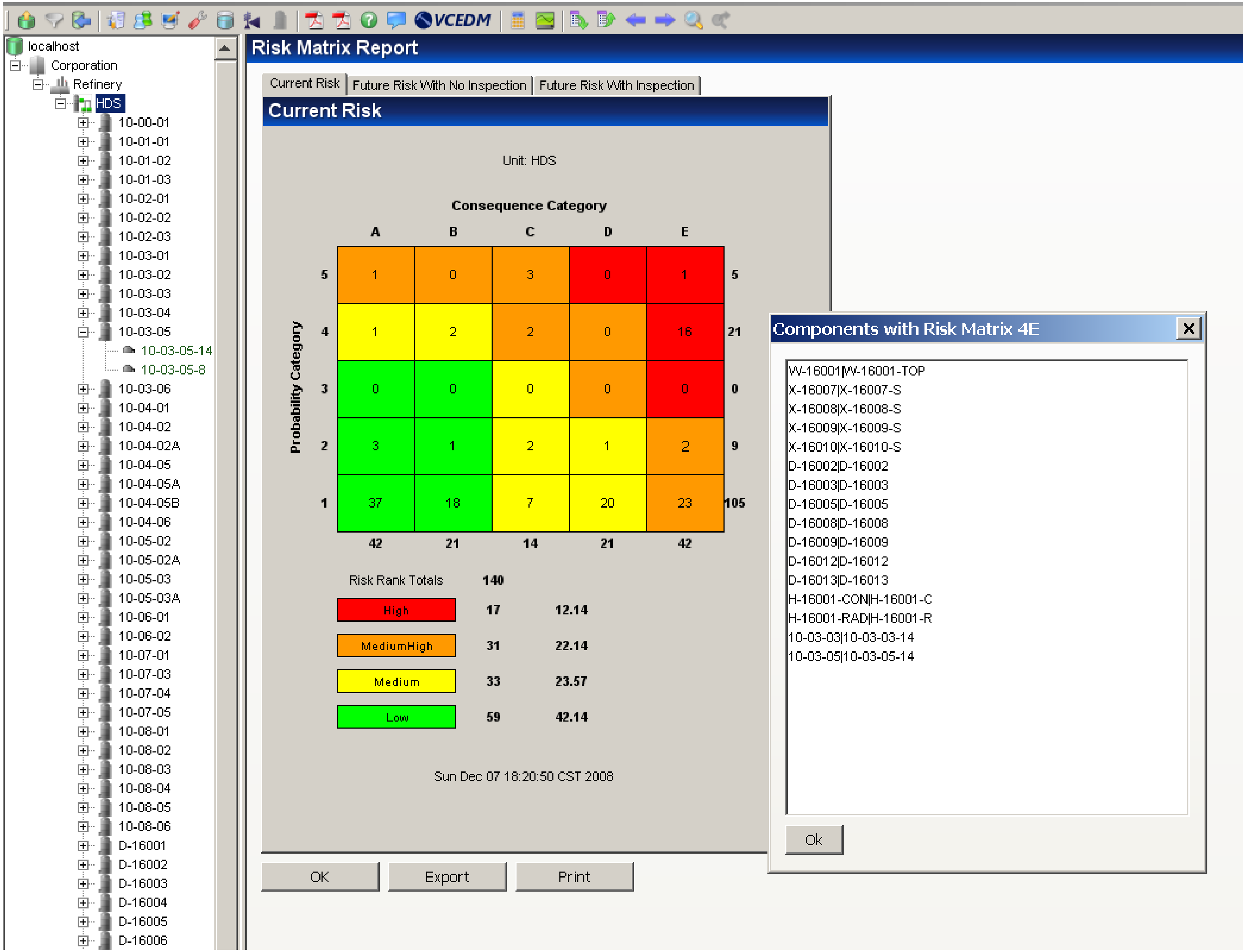
Link to Inspection Database

- Establish basis for linking and sharing data between API RBI and IDBMS program
  - Unit identifier
  - Equipment/Pipe identifier
  - Component/Pipe identifier
- TML Number identifier
- TML Location/Type (shell, pipe, elbow, tee, nozzle, vertical, horizontal)

Inspection Interval

- Half Life inspection due date – Inspection database program based on wall loss from previous inspection date
- RBI due date – Risk based date for inspection based on Risk Target
- Jurisdiction – Inspection based on fixed interval from last inspection


TML/CML INSPECTION PROGRAM
INSPECTION PLANNING
RBI ASSESSMENT
INSPECTION RECOMMENDATIONS
RBI ASSESSMENT DATA
PLAN RBI INSPECTION ACTIVITIES
DOCUMENT INSPECTION & RESULTS


VCEDM
localhost
Corporation
Refinery
HDS
10-00-01
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10-07-03
10-07-04
10-07-05
10-08-01
10-08-02
10-08-03
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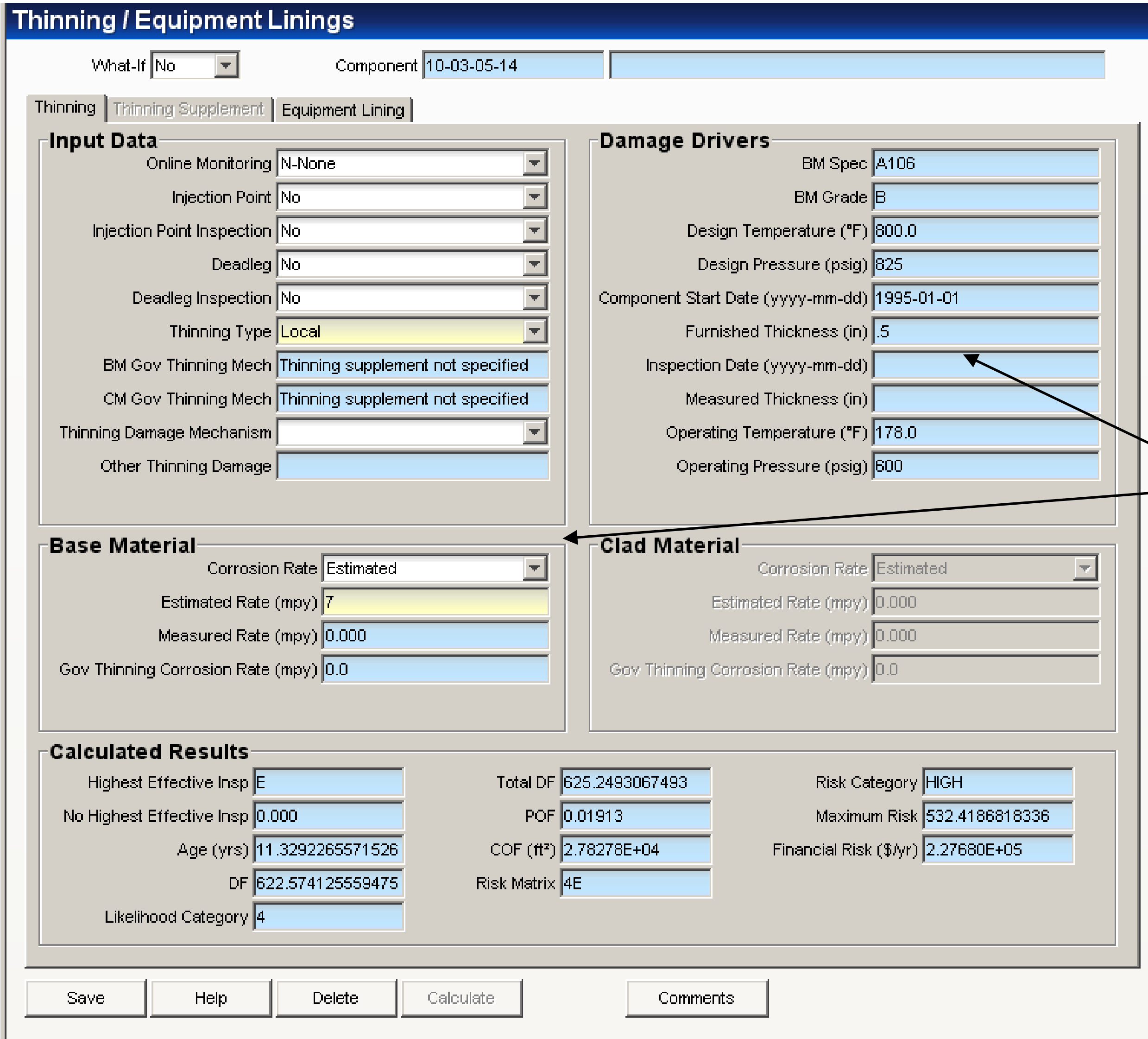
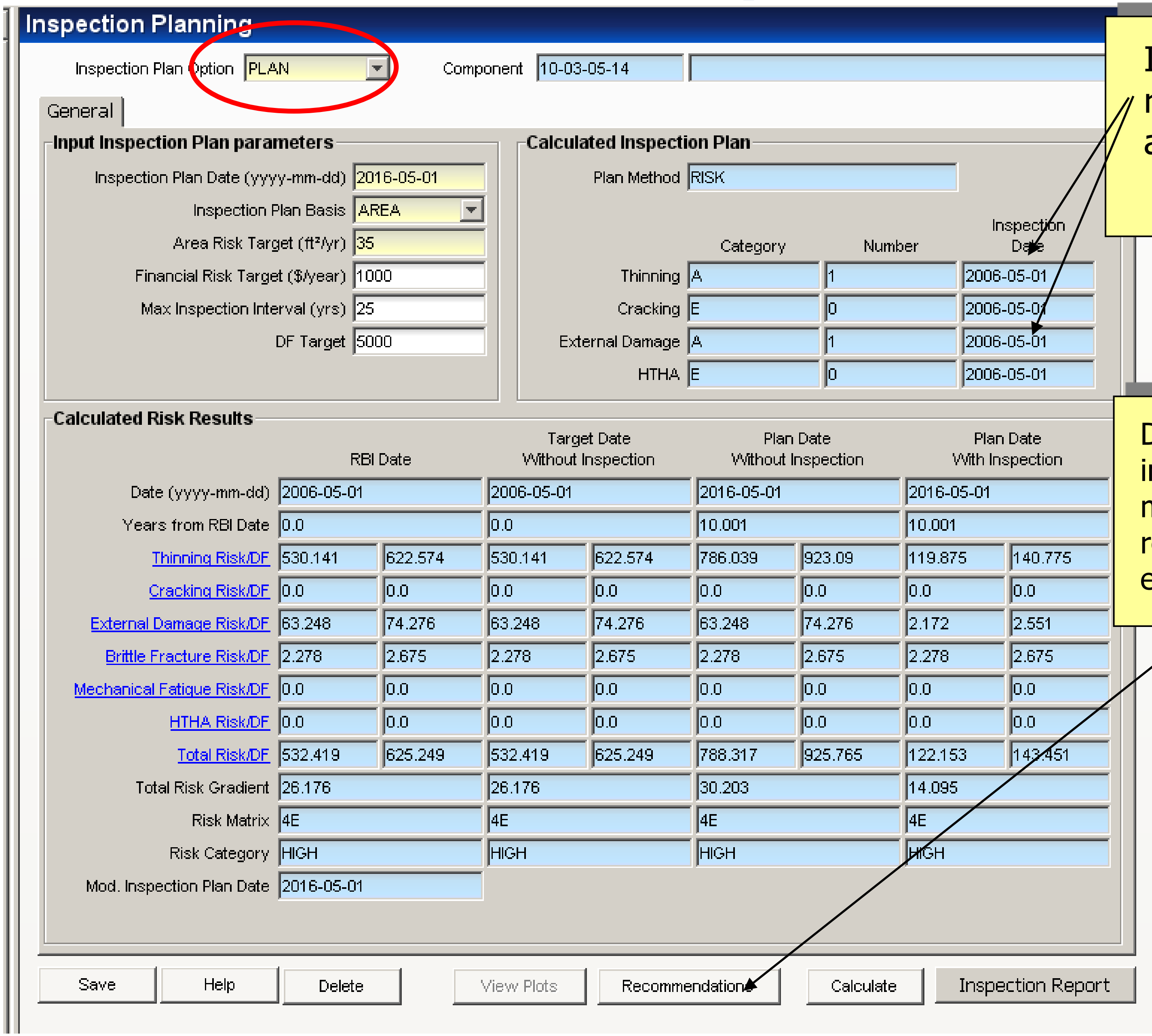
D-16001
D-16002
D-16003
D-16004
D-16005
D-16006
Risk Matrix Report
Current Risk
Future Risk With No Inspection
Future Risk With Inspection
Current Risk
Unit: HDS
Consequence Category
A B C D E
Probability Category
5: 1 0 3 0 1 | 5
4: 1 2 2 0 16 | 21
3: 0 0 0 0 0 | 0
2: 3 1 2 1 2 | 9
1: 37 18 7 20 23 | 105
42 21 14 21 42
Risk Rank Totals 140
High 17 12.14
MediumHigh 31 22.14
Medium 33 23.57
Low 59 42.14
Sun Dec 07 18:20:50 CST 2008
OK
Export
Print
Components with Risk Matrix 4E
W-16001|W-16001-TOP
X-16007|X-16007-S
X-16008|X-16008-S
X-16009|X-16009-S
X-16010|X-16010-S
D-16002|D-16002
D-16003|D-16003
D-16005|D-16005
D-16008|D-16008
D-16009|D-16009
D-16012|D-16012
D-16013|D-16013
H-16001-CON|H-16001-C
H-16001-RAD|H-16001-R
10-03-03|10-03-03-14
10-03-05|10-03-05-14
Ok

API RBI Analysis



Measured corrosion rates and measured thickness by circuit.

API RBI Inspection Planning



Inspection Planning

Inspection Plan Option: PLAN

Component: 10-03-05-14

General

Input Inspection Plan parameters

Inspection Plan Date (yyyy-mm-dd)	2016-05-01
Inspection Plan Basis	AREA
Area Risk Target (ft²/yr)	35
Financial Risk Target ($/year)	1000
Max Inspection Interval (yrs)	25
DF Target	5000

Calculated Inspection Plan

Plan Method: RISK

	Category	Number	Inspection Date
Thinning	A	1	2006-05-01
Cracking	E	0	2006-05-01
External Damage	A	1	2006-05-01
HTHA	E	0	2006-05-01

Calculated Risk Results

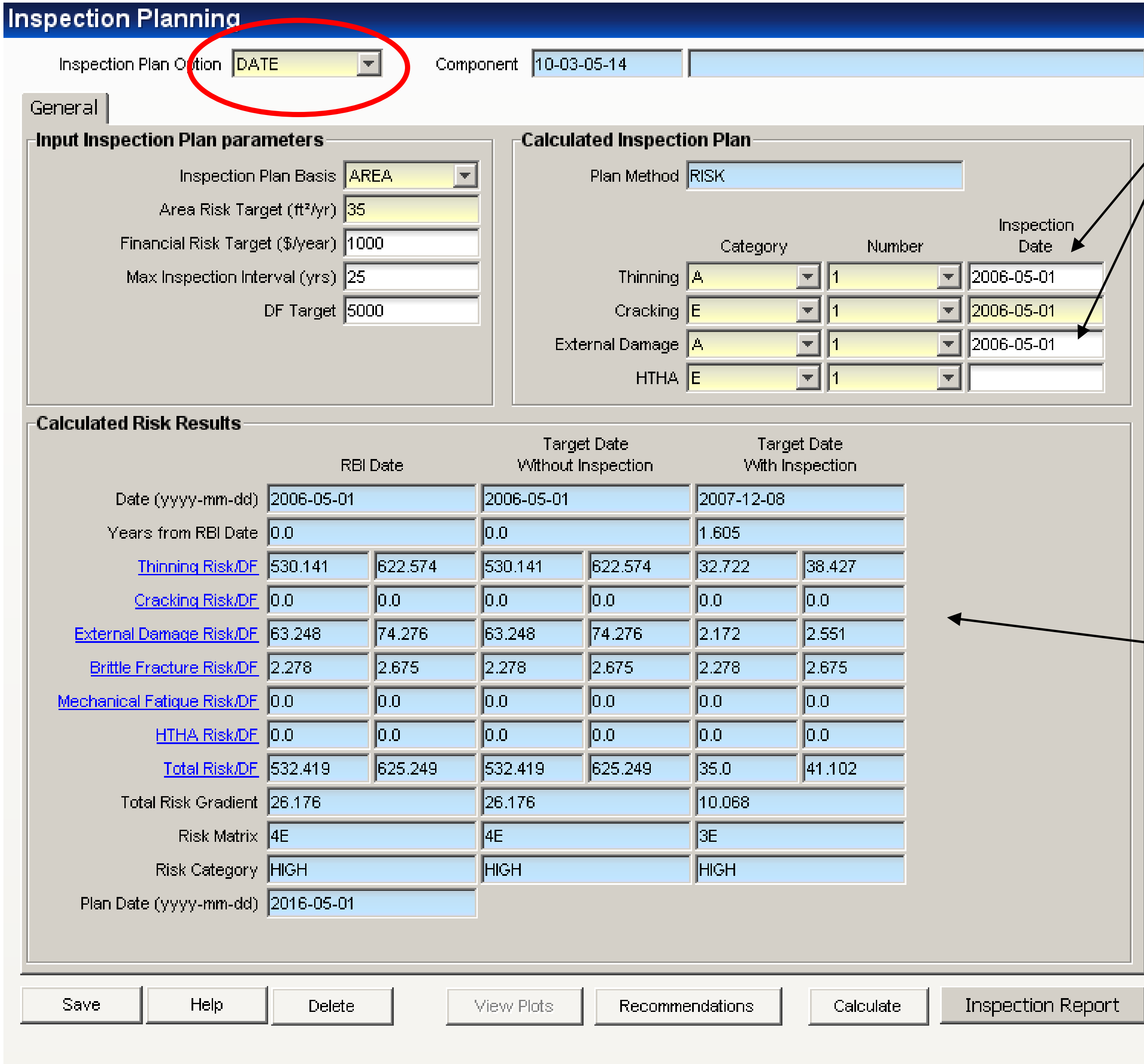
	RBI Date		Target Date Without Inspection		Plan Date Without Inspection		Plan Date With Inspection	
Date (yyyy-mm-dd)	2006-05-01		2006-05-01		2016-05-01		2016-05-01	
Years from RBI Date	0.0		0.0		10.001		10.001	
Thinning Risk/DF	530.141	622.574	530.141	622.574	786.039	923.09	119.875	140.775
Cracking Risk/DF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
External Damage Risk/DF	63.248	74.276	63.248	74.276	63.248	74.276	2.172	2.551
Brittle Fracture Risk/DF	2.278	2.675	2.278	2.675	2.278	2.675	2.278	2.675
Mechanical Fatigue Risk/DF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTHA Risk/DF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Risk/DF	532.419	625.249	532.419	625.249	788.317	925.765	122.153	143.451
Total Risk Gradient	26.176		26.176		30.203		14.095	
Risk Matrix	4E		4E		4E		4E	
Risk Category	HIGH		HIGH		HIGH		HIGH	
Mod. Inspection Plan Date	2016-05-01							

Save | Help | Delete | View Plots | Recommendations | Calculate | Inspection Report

Inspection recommendations and due date.

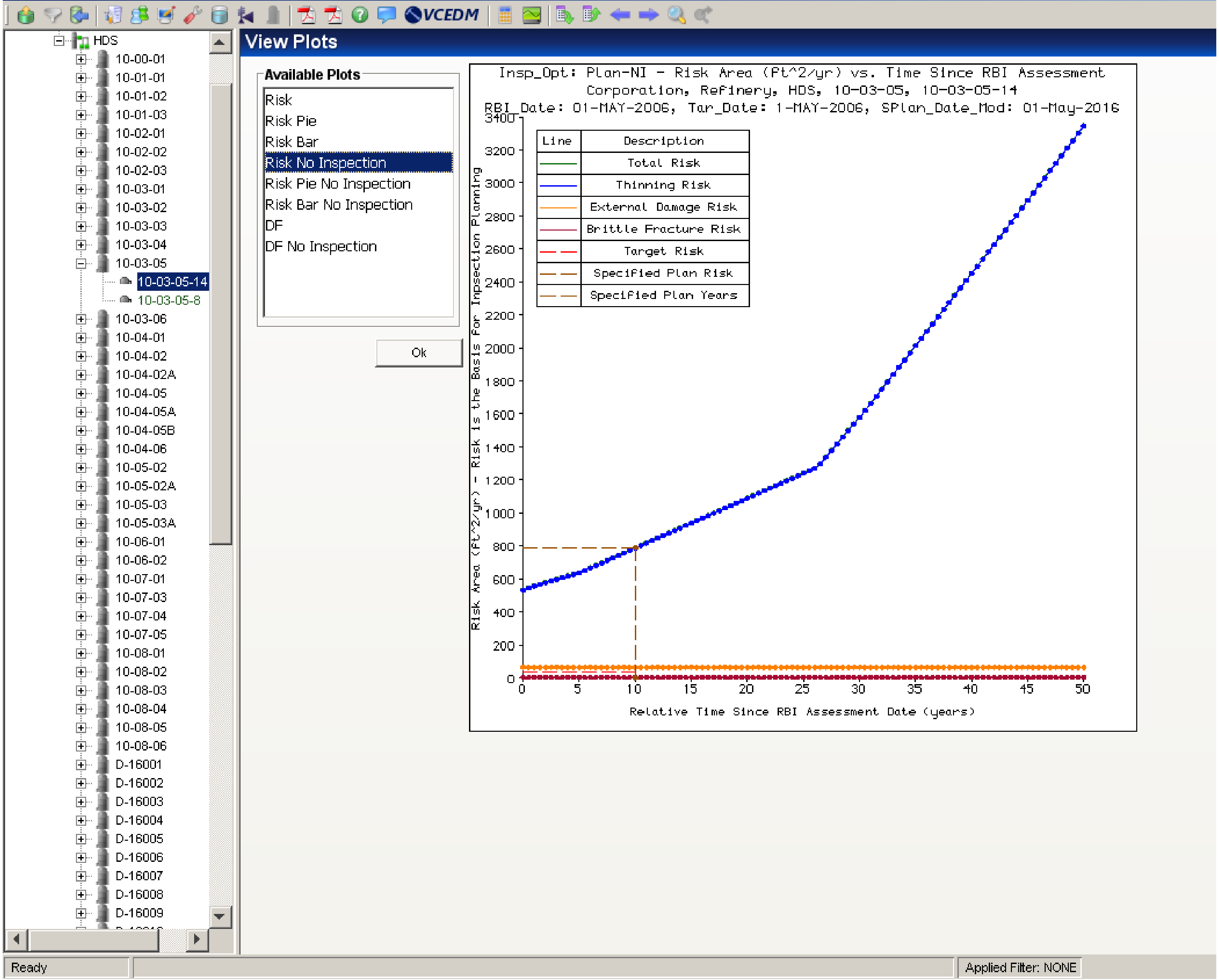
Detailed inspection plans include scope, damage mechanism and recommended inspection effectiveness.

API RBI Inspection Planning



Actual Planned Inspection dates

Risk Associated with Inspection



VCEDM
HDS
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10-03-04
10-03-05
10-03-05-14
10-03-05-8
10-03-06
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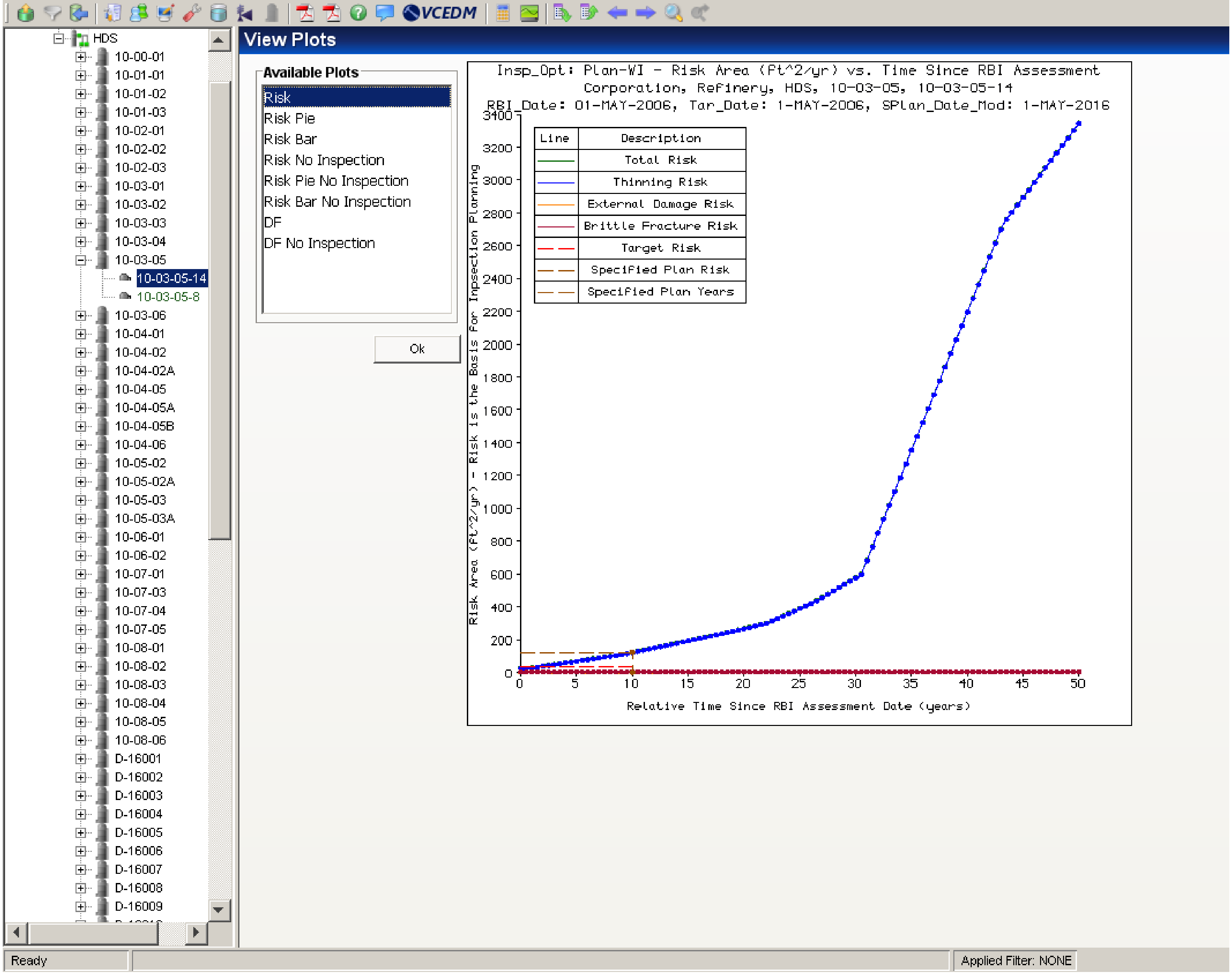
10-08-06
D-16001
D-16002
D-16003
D-16004
D-16005
D-16006
D-16007
D-16008
D-16009
View Plots
Available Plots
Risk
Risk Pie
Risk Bar
Risk No Inspection
Risk Pie No Inspection
Risk Bar No Inspection
DF
DF No Inspection
Ok
Insp_Opt: Plan-NI - Risk Area (ft^2/yr) vs. Time Since RBI Assessment
Corporation, Refinery, HDS, 10-03-05, 10-03-05-14
RBI_Date: 01-MAY-2006, Tar_Date: 1-MAY-2006, SPlan_Date_Mod: 01-May-2016
Line
Description
Total Risk
Thinning Risk
External Damage Risk
Brittle Fracture Risk
Target Risk
Specified Plan Risk
Specified Plan Years
Risk Area (ft^2/yr) - Risk is the Basis for Inspection Planning
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
0
5
10
15
20
25
30
35
40
45
50
Relative Time Since RBI Assessment Date (years)
Ready
Applied Filter: NONE


VCEDM
HDS
10-00-01
10-01-01
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10-01-03
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10-03-02
10-03-03
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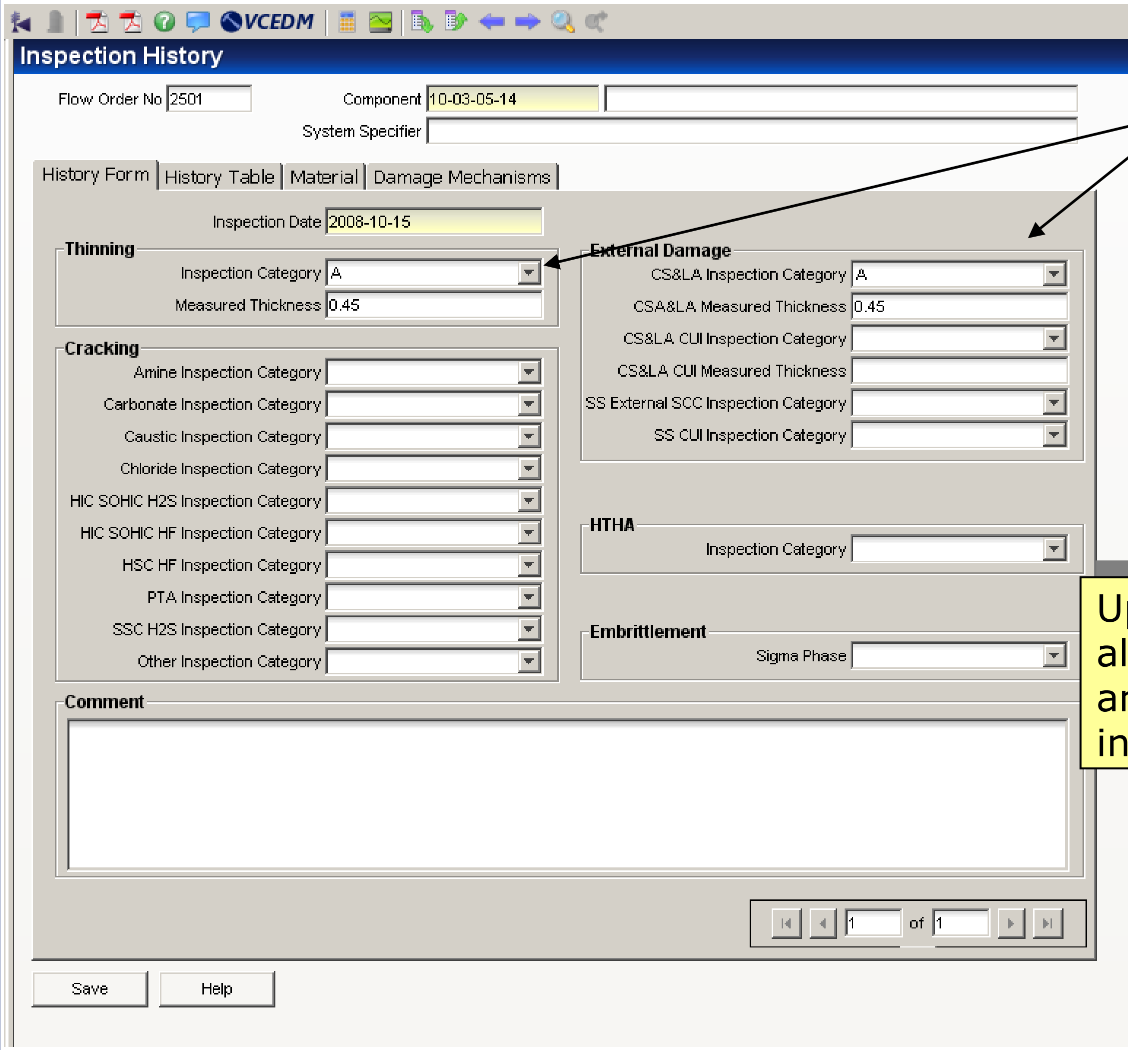
10-08-06
D-16001
D-16002
D-16003
D-16004
D-16005
D-16006
D-16007
D-16008
D-16009
View Plots
Available Plots
Risk
Risk Pie
Risk Bar
Risk No Inspection
Risk Pie No Inspection
Risk Bar No Inspection
DF
DF No Inspection
Ok
Insp_Opt: Plan-WI - Risk Area (Ft^2/yr) vs. Time Since RBI Assessment
Corporation, Refinery, HDS, 10-03-05, 10-03-05-14
RBI_Date: 01-MAY-2006, Tar_Date: 1-MAY-2006, SPlan_Date_Mod: 1-MAY-2016
Line
Description
Total Risk
Thinning Risk
External Damage Risk
Brittle Fracture Risk
Target Risk
Specified Plan Risk
Specified Plan Years
Risk Area (Ft^2/yr) - Risk is the Basis for Inpsection Planning
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
0
5
10
15
20
25
30
35
40
45
50
Relative Time Since RBI Assessment Date (years)
Ready
Applied Filter: NONE

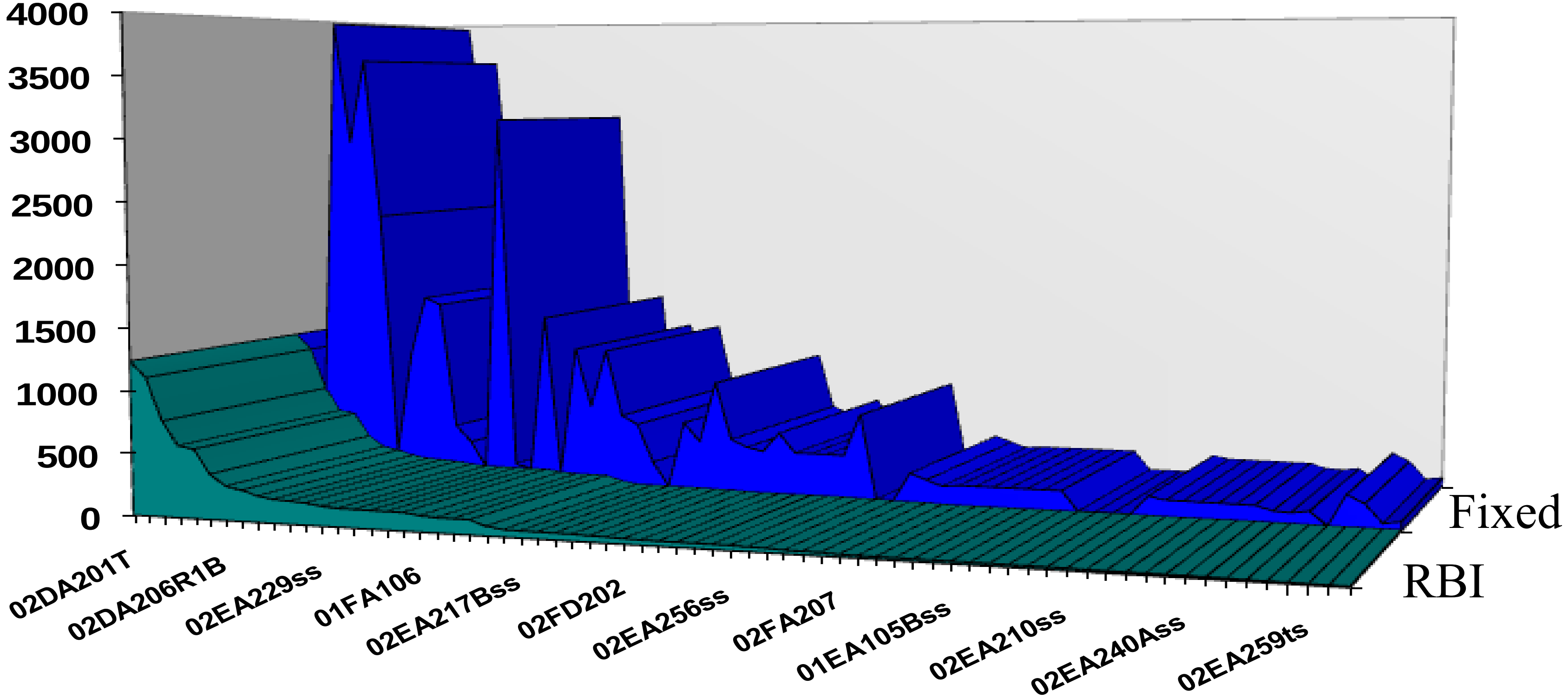
Inspection Results into API RBI



Record actual inspection effectiveness and measured thickness to be used in Risk determination

Updated measured corrosion rate also entered in Thinning Module and Risk recalculated for next interval recommendation.

Risk After Inspection



Inspection Results

- Inspection results and findings should be compared to expectations of damage
  - Thinning rate and type (general or localized)
  - Cracking inspection findings – if cracking was found and severity, if found
- Were there any inspection findings that could impact the RBI Assessment?
- Are there any MOC considerations that could impact the Risk Assessment?
- Any new information or findings should be noted and returned to the RBI analysis Team

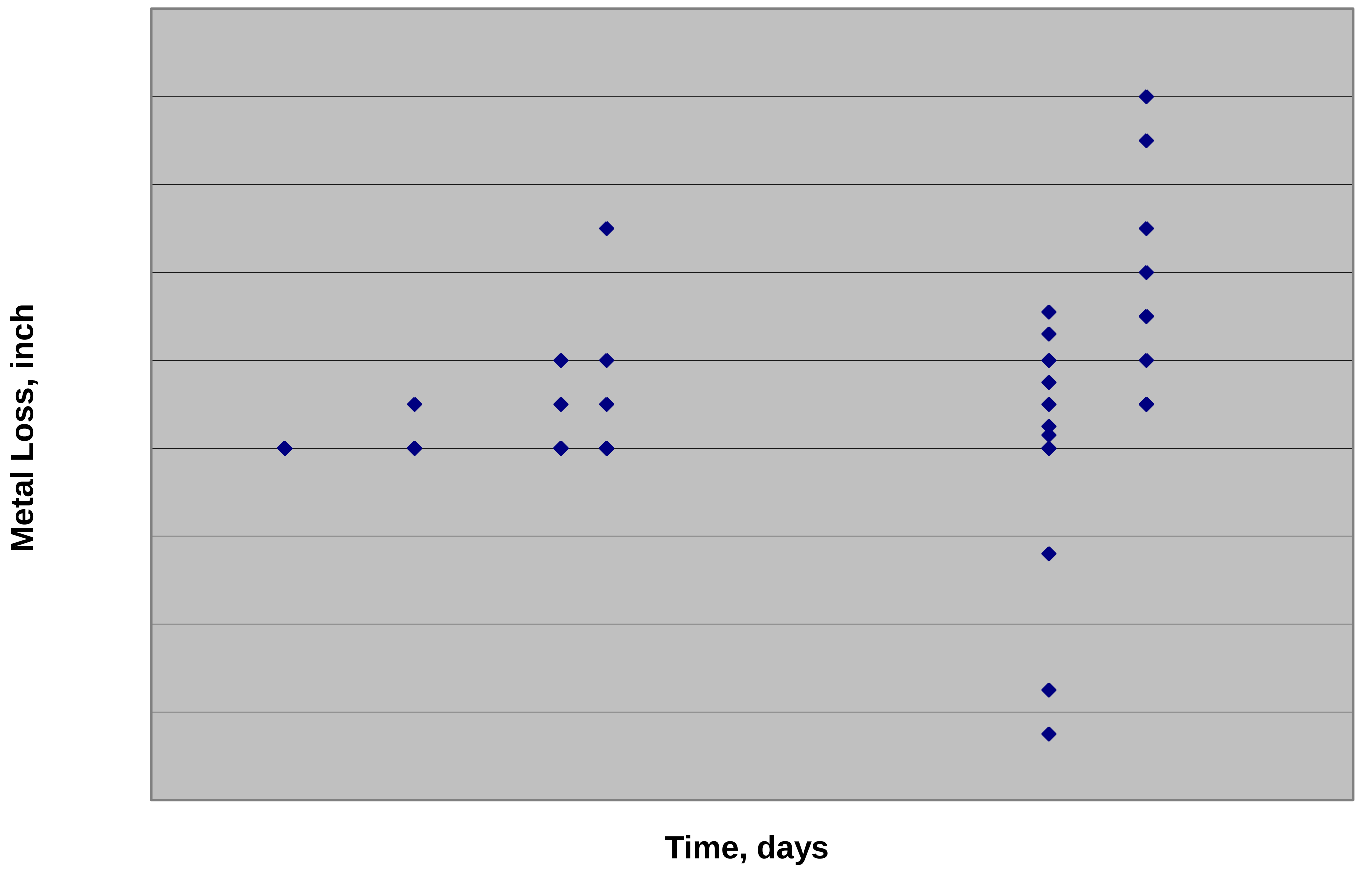
Piping TML/CML Analysis

- Piping systematized and circuitized based on corrosion circuits
- Pipe line numbers identified on isometric drawings and grouped by assigned systems and circuits
- RBI component name linked to IDBMS program
- Thickness data by circuit evaluated
- Analysis:
  - Average measured corrosion rate by circuit compared to estimated rates in RBI program
  - Statistically evaluated thickness data determine measurement confidence and variability

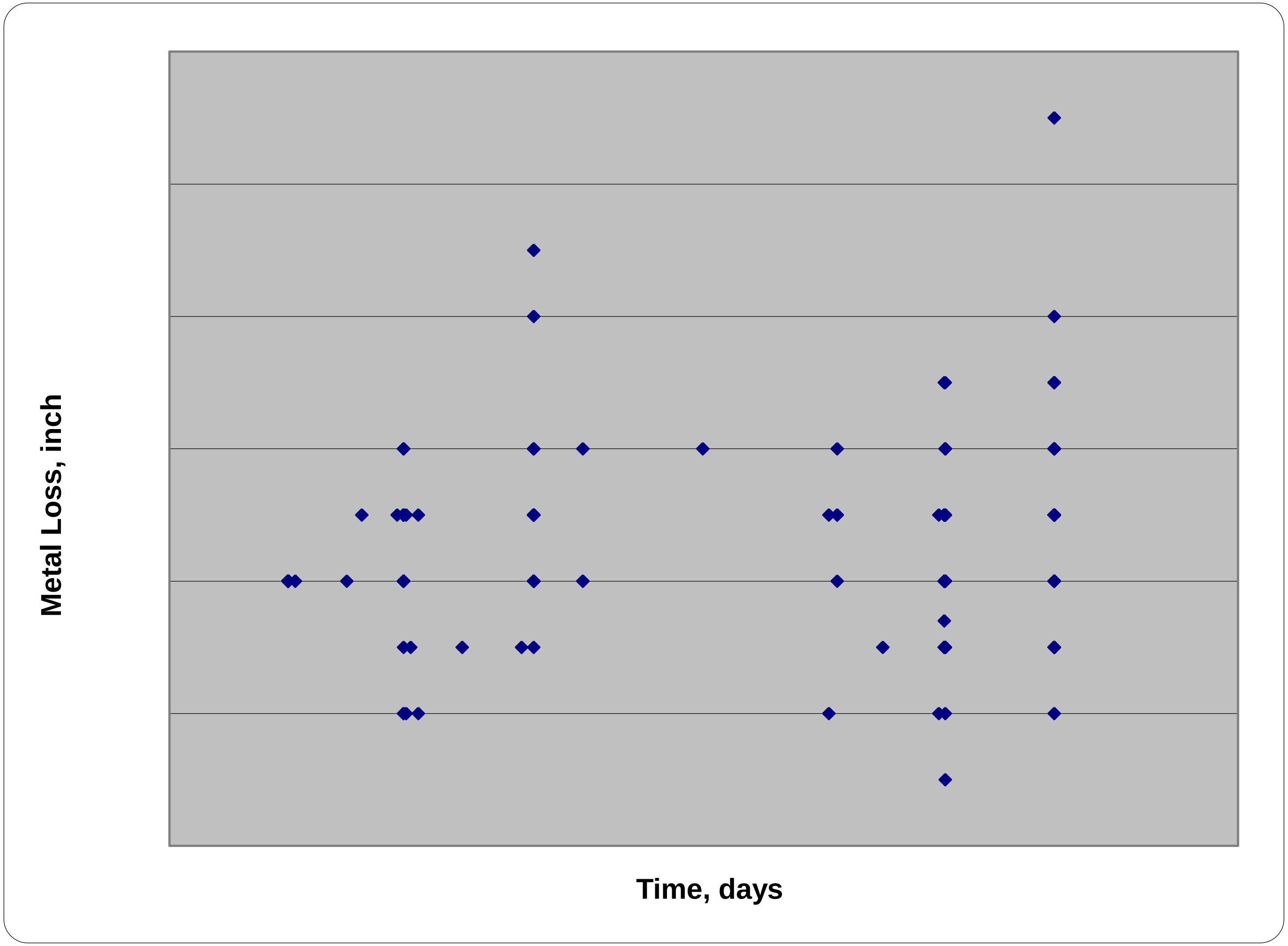
Piping TML/CML Analysis

- Data from IDBMS program grouped by RBI defined system and circuits
- Analysis of thickness measurement data by:
  - Equipment thickness data
    - + Remove fabrication type and specific flow conditions that might increase variability
  - Component thickness data
    - + Evaluate diameter (thickness) contribution to measurement variability
    - + Remove fabrication type and specific flow conditions that might increase variability
    - + Evaluate diameter (thickness) contribution to measurement variability

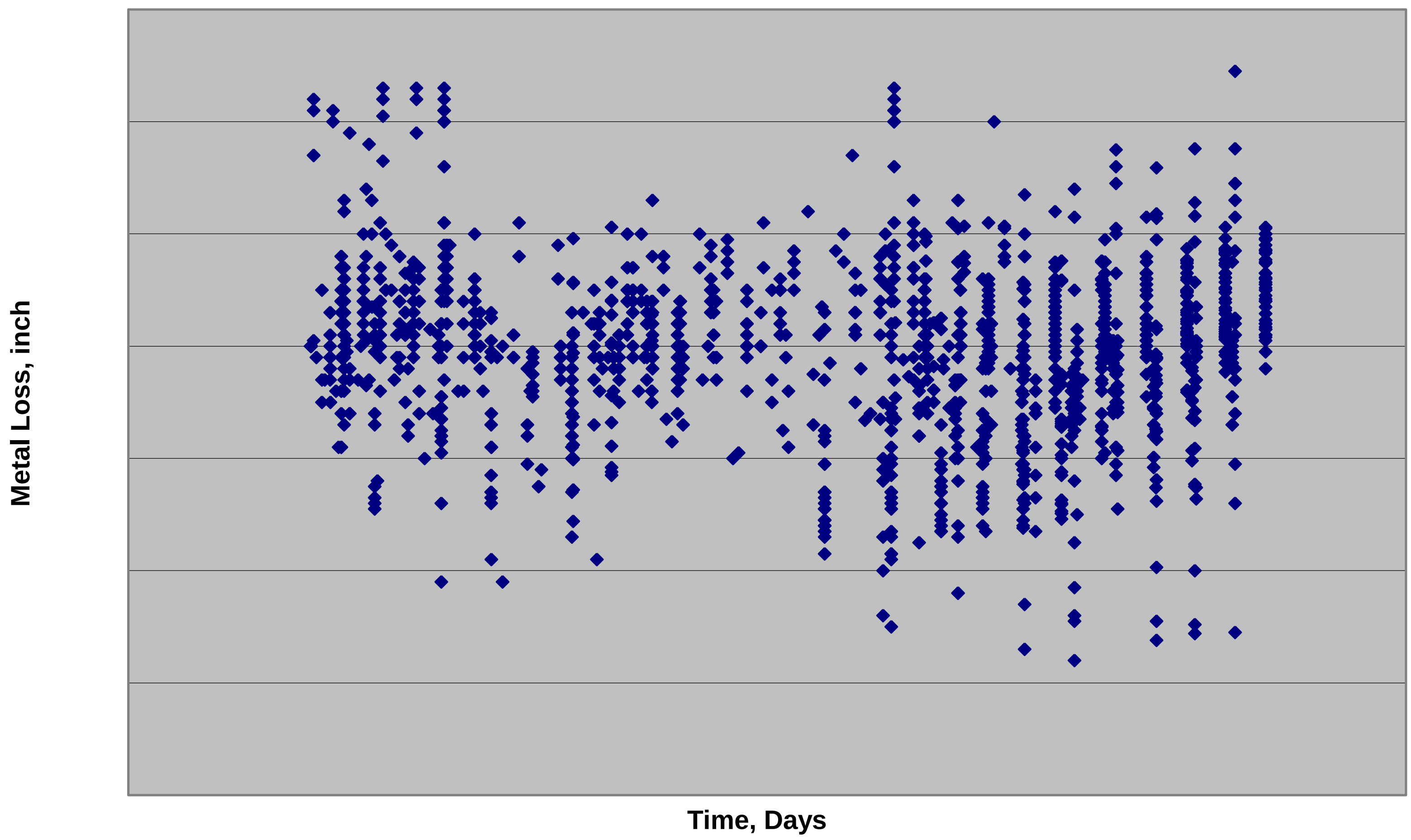
Piping TML/CML Analysis Example



Piping TML/CML Analysis Example



Piping TML/CML Analysis Example



Piping TML/CML Analysis

- High data variability can be an indication of higher than expected corrosion rates and/or localized corrosion
- Data from TML measurements show a wide range of wall loss over time
  - +/- 0.02 considered good data
  - +/- 0.08 average data
  - > +/- 0.10 considered poor quality data
- High TML data variation can mask indications of localized thinning

Piping Program Benefits

- Groups components (i.e., circuits) where active damage mechanisms and damage rates are similar
- Allows comparison of measured data and corrosion rates with historical or expected rates as well as localized behavior
- Provides information for defining appropriate coverage of CML/TML as well as other more appropriate inspection methods
- May identify undetected or localized corrosion issues that exist
- Calculates Risk and recommends inspection at circuit level
- Identifies and documents:
  - Multiple potential damage mechanisms
  - Special inspection needs (such as deadlegs, mix points or high risk equipment)
  - Process treatment and monitoring programs, chemical injection, water wash and fouling, etc.

TML/CML Analysis Conclusions

- User must consider:
  - Inherent thickness measurement error with or without a qualified procedure
  - Expected wall loss rate being measured (compared to UT accuracy)
  - Inspection intervals for wall loss detection
- Improved quality and accuracy of thickness measurements are needed to improve analysis capability
- Criteria provided to inspectors before field measurements are taken could significantly improve data quality
- More analysis and trending is necessary to understand the data and define requirements for improving TML inspection quality

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Houston, TX 77058 USA
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