RCA Name	Slurry pump seal leakage
Report Number	2012-B201
Report Date	12/3/2012
RCA Owner	C. Eckert

Root Cause Analysis Report

Problem Statement

Focal Point 20 hours of production outage (Pump seal replacement)

When

Start Date	11/21/2012	End Date	11/22/2012
Start Time	14:00	End Time	10:00
Unique Timing	2 weeks after pump was installed as part of capital project		

Where

Business Unit	Performance products
Location	Crump, Michigan, USA
System	Reaction step
Component	P-105

Actual Impact

		Cost
Safety	None	$0.00
Environmental	500 lbs of methyl bad-stuff leaked into dike; contained	$0.00
Revenue	Lost profit due to 20 hours downtime (Plant is sold out). Delays in getting product to market	$100,000.00
Cost	Pump repair; labor & parts	$15,000.00
Cost	Clean up	$1,500.00
Environmental	Disposal of spilled methyl bad-stuff	$3,000.00
	Actual Impact Total:	$119,500.00

Frequency	1 times per week
Frequency Notes	Pump has been replaced twice in last 2 weeks, so total cost so far is ~$240k.

Potential Impact

Safety	Potential exposure to skin irritant from leaking seal	$0.00
Revenue	Annualized loss at current rate. Losses could grow if demand grows per expected market projections	$5,200,000.00
	Potential Impact Total:	$5,200,000.00

Report Summaries

Executive Summary

The repeat failure of the new P-105 slurry pump has caused repeat, unplanned shutdowns resulting in lost profit and excessive expenditures due to seal leaks. The slurry contains 50% methyl bad stuff which is an environmentally regulated chemical and requires the pump to be shut down upon detection of a leak greater than 2kg/hr causing production losses amounting to $240,000 thus far. These losses will increase as product demand grows.The project team was under cost- and timing- pressure, and specified a seal that was not suitable for this service.

In order to prevent repeat seal failures, the corrective action is to install a new type of seal and stuffing box capable of handling the solids. The preventive actions are to integrate a reliability review with all new capital projects and to require the area reliabilty engineer to provide design criteria to the project teams for special, known process and equipment requirements.

Cause and Effect Summary

The unplanned shutdown was caused by a seal leak of slurry pump P-105. The seal leak was the result of a single mechanical seal being installed in slurry service. Single mechanical seals with discharge recirc flushes in slurry service fail due to solids depositing on the seal faces. Deposits open the seal faces as the pumped liquid evaporates across the seal faces, leaving solids behind. This opens the seal faces creating increasingly worse seal leakage. The single mechanical seal was installed because the project team didn't know it was not the best choice, and because it was inexpensive. The team didn't know it wasn't the best choice because they didn't seek reliability input and because no one gave them input upfront as to the most effective design criteria for the process and equipment requirements. The missing input was caused by no step, or requirement, in the capital project guidelines to integrate reliability input. The project team also went with the single seal because they were looking to cut costs due to budget contraints imposed on them by the business and because they were projected to be over budget. They were also in a rush to complete the project in order to get the product to market more quickly.

Solutions

ID	Label	Description		
1	**Solution**	Replace single seal with double mechanical seal		
	Cause	Single mechanical seal on pump		
	Note			
	Assigned	Bill Wilson	**Criteria**	Pass
	Due	12/26/2012	**Status**	Approved
	Term	Short	**Cost**	$10,000.00
2	**Solution**	Modify capital project steps to include R&M review		
	Cause	New pump did not receive reliability review		
	Note			
	Assigned	Sue Young	**Criteria**	Pass
	Due	2/3/2013	**Status**	Approved
	Term	Medium	**Cost**	$800.00
3	**Solution**	Modify capital project steps to have reliability engineer provide list of key design critieria for new equipment		
	Cause	Design choice by capital project team		
	Note			
	Assigned	Bill Wilson	**Criteria**	Pass
	Due	2/3/2013	**Status**	Approved
	Term	Medium	**Cost**	$0.00
4	**Solution**	Install seal-less pump		
	Cause	Single mechanical seal on pump		
	Note	Not confident that seal-less pump would be able to handle the large solids present		
	Assigned	Choose	**Criteria**	Fail
	Due		**Status**	Identified
	Term	Choose	**Cost**	$0.00
5	**Solution**	Replace conventional stuffing box with taper bore stuffing box		
	Cause	Conventional stuffing box installed		

Note			
Assigned	Choose	**Criteria**	Pass
Due	12/26/2012	**Status**	Selected
Term	Short	**Cost**	$2,000.00

Team

ID	Label	Description	Label	Description
1	**First Name**	Bill	**Last Name**	Wilson
	Phone (1)		**Phone (2)**	
	Role	Rel eng	**Group**	
	Email	bw@stuff.com		
2	**First Name**	Sue	**Last Name**	Young
	Phone (1)		**Phone (2)**	
	Role	Proj eng	**Group**	
	Email	sy@stuff.com		
3	**First Name**	Dan	**Last Name**	Valerio
	Phone (1)		**Phone (2)**	
	Role	Machinist	**Group**	
	Email	dv@stuff.com		
4	**First Name**	Chris	**Last Name**	Eckert
	Phone (1)		**Phone (2)**	
	Role		**Group**	
	Email	chris.eckert@sologic.com		

Evidence

ID	Label	Description
1	**Evidence**	visual observation
	Cause(s)	Single seal ordered with new pump Single mechanical seal on pump Pump was running Pump P-105 seal leaking excessively Solids stick to faces Inexperienced project team No clean, external seal flush Pump not upgraded after installation Solids in fluid accumulate on seal faces Accumulated solids opens faces Conventional stuffing box installed Solids not flushed away Face materials are the same One face is stationary Total turnaround time = 20 hours 1 hour to LOTO 1 hour to flush and drain 1 hr for LEO and disconnection 3 hours to reinstall 2 hours to de-LEO and recommission 12 hours to replace seal in shop
	Location	
	Link	
	Contributor	Bill Wilson
	Type	Direct Observation
	Quality	★★★★☆
2	**Evidence**	EH&S Manager statement
	Cause(s)	Desire to be in compliance with all environmental regulations Pump handles regulated chemical Desire to be good environmental stewards Decision not to exceed allowable emissions Pumped fluid is skin irritant Leaking seal is safety hazard
	Location	
	Link	

	Contributor	Choose
	Type	Direct Statement
	Quality	★★★★☆

3	**Evidence**	Project engineer statement
	Cause(s)	Reliability group never provided feedback No reliability personnel assigned to project team Single seal is relatively inexpensive Project team needed to save money Project team over-ran budget Design choice by capital project team Fast track Project Inexperienced project team No one recognized the need Capital projects group never asked Reliability input not required in project guiidelines New pump did not receive reliability review No design standards for this application No information or knowledge to spec anything different Single seal ordered with new pump
	Location	
	Link	
	Contributor	Choose
	Type	Direct Statement
	Quality	★★★★☆

4	**Evidence**	Seal mfg literature
	Cause(s)	Single mechnical seals unable to tolerate solids Accumulated solids opens faces Liquid vaporizes Small amount of pumped fluid leaks across seal faces Conventional stuffing boxes unable to effectively purge solids Seal faces run hotter than liquid boiling point Heat generated by seal face friction Inability to cool faces High friction coefficient One face is stationary One face rotates
	Location	
	Link	http://www.flowserve.com/Products/Seals

Contributor	Chris Eckert
Type	Document
Quality	★★★★★

5

Evidence	Machinist statement
Cause(s)	Single seal is relatively inexpensive Single mechanical seal on pump Accumulated solids opens faces Pumped fluid contains solids Capital projects group never asked Pump not upgraded after installation No clean, external seal flush Solids stick to faces Conventional stuffing boxes unable to effectively purge solids
Location	
Link	
Contributor	Choose
Type	Direct Statement
Quality	★★★★☆

6

Evidence	Operations Supv statement
Cause(s)	System under pressure Choose not to run with leaking seal Decision to repair pump P-105
Location	
Link	
Contributor	Choose
Type	Direct Statement
Quality	★★★★☆

Actions & Chart Quality

Custom Actions - 1

ID	Label	Description	
149	**Action**	Determine type of stuffing box	
	Cause	Conventional stuffing box installed	
	Assigned	Choose	**Due Date**
	Completed	no	

Evidence - 1

Termination Points - 6

Cause Types - 0

Unconnected Causes - 0

Empty Cause Boxes - 0

Notes

ID	Label	Description
1	**Note**	Machinists checked clearances and tolerances, and all looked in accordance with spec
	Cause	Seal Improperly installed?
2	**Note**	Speed to market was key to successful product launch
	Cause	Fast track Project
3	**Note**	Verified steps
	Cause	Seal Improperly installed?

Chart Type Legend
- Transitory
- Non-transitory
- Omission - Transitory
- Omission - Non-transitory
- Focal Point
- Solution Implemented

Report and chart generated by Sologic's Causelink software.
sologic
Logical analysis | Powerful solutions
www.sologic.com

20 hours of production outage (Pump seal replacement)

Evidence: Operations Supv statement

Decision to repair pump P-105

Choose not to run with leaking seal

Evidence: Operations Supv statement

and

Pump handles regulated chemical → END
Terminated because: Other causal paths more productive
Evidence: EH&S Manager statement

Decision not to exceed allowable emissions

Evidence: EH&S Manager statement

Desire to be in compliance with all environmental regulations → END
Terminated because: Desired state
Evidence: EH&S Manager statement

Desire to be good environmental stewards → END
Terminated because: Desired state
Evidence: EH&S Manager statement

Leaking seal is safety hazard

Evidence: EH&S Manager statement

Pumped fluid is skin irritant → END
Terminated because: Other causal paths more productive
Evidence: EH&S Manager statement

Pump was running → END
Terminated because: Desired state
Evidence: visual observation

System under pressure → END
Terminated because: Desired state
Evidence: Operations Supv statement

Pump P-105 seal leaking excessively

Evidence: visual observation

Risk

Single mechanical seal on pump

Evidence: visual observation; Machinist statement

Solutions

Replace single seal with double mechanical seal
Criteria Pass Status Approved

Install seal-less pump
Criteria ⚠ Status Identified
Not confident that seal-less pump would be able to handle the large solids present

Single seal ordered with new pump

Evidence: visual observation; Project engineer statement

Pump not upgraded after installation

Evidence: visual observation; Machinist statement

Connects to: c No one recognized the need

Production can't run without P-105 → END
Terminated because: Other causal paths more productive

Total turnaround time = 20 hours

Evidence: visual observation

1 hour to LOTO

Evidence: visual observation

1 hr for LEO and disconnection

Evidence: visual observation

12 hours to replace seal in shop

Evidence: visual observation

3 hours to reinstall

Evidence: visual observation

2 hours to de-LEO and recommission

Evidence: visual observation

1 hour to flush and drain

Evidence: visual observation

and

Seal Improperly installed? → END
Terminated because: Other causal paths more productive

Single seal design unable to handle pumped fluid

Pumped fluid contains solids → END
Terminated because: Other causal paths more productive
Evidence: Machinist statement

Single mechnical seals unable to tolerate solids

Evidence: Seal mfg literature

Solids in fluid accumulate on seal faces

Evidence: visual observation

Accumulated solids opens faces

Evidence: visual observation; Seal mfg literature; Machinist statement

Solids not flushed away

Evidence: visual observation

Conventional stuffing box installed

Evidence: visual observation

Solutions

Replace conventional stuffing box with taper bore stuffing box
Criteria Pass Status Selected

Connects to: a No information or knowledge to spec anything different

Conventional stuffing boxes unable to effectively purge solids → END
Terminated because: Other causal paths more productive
Evidence: Seal mfg literature; Machinist statement

No clean, external seal flush

Evidence: visual observation; Machinist statement

Connects to: b No information or knowledge to spec anything

Design choice by capital project team

Evidence: Project engineer statement

Solutions

Modify capital project steps to have reliability engineer provide list of key design critieria for new equipment
Criteria Pass Status Approved

Single seal is relatively inexpensive

Evidence: Project engineer statement; Machinist statement

Project team needed to save money

Evidence: Project engineer statement

Risk

Project team over-ran budget → END
Terminated because: New RCA needed
Evidence: Project engineer statement

No information or knowledge to spec anything different

Evidence: Project engineer statement

New pump did not receive reliability review

Evidence: Project engineer statement

Solutions

Modify capital project steps to include R&M review
Criteria Pass Status Approved

No design standards for this application

Evidence: Project engineer statement

Liquid vaporizes

Evidence: Seal mfg literature

Solids stick to faces → END
Terminated because: Other causal paths more productive
Evidence: visual observation; Machinist statement

Fast track Project → END
Terminated because: Other causal paths more productive
Evidence: Project engineer statement

No reliability personnel assigned to project team

Evidence: Project engineer statement

Small amount of pumped fluid leaks across seal faces → END
Terminated because: Other causal paths more productive
Evidence: Seal mfg literature

Seal faces run hotter than liquid boiling point

Evidence: Seal mfg literature

Heat generated by seal face friction

Evidence: Seal mfg literature

Inability to cool faces → END
Terminated because: Other causal paths more productive
Evidence: Seal mfg literature

No one recognized the need

Evidence: Project engineer statement

Reliability input not required in project guidelines → END
Terminated because: Other causal paths more productive
Evidence: Project engineer statement

Inexperienced project team → END
Terminated because: Other causal paths more productive
Evidence: visual observation; Project engineer statement

Reliability group never provided feedback → END
Terminated because: Other causal paths more productive
Evidence: Project engineer statement

Capital projects group never asked

Evidence: Project engineer statement; Machinist statement

Risk

One face rotates → END
Terminated because: Other causal paths more productive
Evidence: Seal mfg literature

One face is stationary → END
Terminated because: Other causal paths more productive
Evidence: visual observation; Seal mfg literature

High friction coefficient

Evidence: Seal mfg literature

Face materials are the same → END
Terminated because: Other causal paths more productive
Evidence: visual observation