Maximising Maintenance Work Quality and Equipment Reliability in Shutdowns

Shutdowns and Turnarounds 2011 Conference

By

Mike Sondalini
Lifeime Reliability Solutions

www.lifetime-reliability.com
Presentation Coverage

• The connection between maintenance work quality and the time to the next breakdown,

• Using the Taguchi Loss Function to explain why work quality is important,

• Effectively specifying and measuring maintenance work quality requirements for shutdowns
Shell’s Shutdown Success Indicators

- **True Shutdown Duration**
  Total time taken from feed out to product back on grade

  - Feed out
  - Product on spec

- **Length of Interval Between Shutdowns**
  Time between planned shutdowns
  (from product on grade to feed out of two consecutive shutdowns)

  - S/D interval

Some ‘best’ numbers in Refining Source: Alberto Pasqualini refinery – Brazil

- Crude unit run 68 months (5-3/4 yrs)
- Crude unit “pioneer” run 90 months (7-3/4 yrs)
- Catalytic Cracker run 46 months (3-3/4 yrs)

Thanks to Jim Wardhaugh, UK Consultant (30 years with Shell and Centre of Excellence Leader)

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Influence on Profitability

High
- Good Operation – Steady and Stable
- Shutdown Avoidance – Degradation Mgmt
- Strategy/Objectives to Reduce Maintenance
- Minimise Size to Reduce Resources

Low
- Excellent Preparation

Years to shutdown

Thanks to Jim Wardhaugh, UK Consultant (30 years with Shell and Centre of Excellence Leader)

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The Concept of a Quality Loss Function

Loss Functions can take a range of shapes
Distribution of Work Quality Performance

- TERRIBLE RELIABILITY
  (Early Life Breakdowns)

- TERRIFIC RELIABILITY
  (Exceptional Service Life)

Frequency of Outcome

Maintenance Work Quality

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Combining Work Quality and Loss Function

Cost of Loss/Waste

Frequency of Outcome

Minimum Loss

Lower

OPTIMUM

Upper

TERRIBLE

TERRIFIC

Maintenance Work Quality

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Work Quality that Minimises Loss and Waste

![Graph showing the relationship between work quality, cost of loss, and frequency of outcome. The graph illustrates the concept of minimum loss at the optimum quality level.](image)
Work Quality that Optimises Reliability

![Graph showing the relationship between work quality, maintenance, and reliability]

- **Frequency of Outcome**
- **Cost of Loss**

- **Minimum Loss**
- **Lower**
  - **OPTIMUM RELIABILITY**
- **Upper**
  - **TERRIFIC**
  - **TERRIBLE**

**Maintenance Work Quality**

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Work Quality that Makes Money

Cost of Loss

Frequency of Outcome

Lower

OPTIMUM

Upper

Minimum Loss

TERRIBLE

TERRIBLE

TERRIFIC

TERRIFIC

Maintenance Work Quality

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Where the Money Comes from by doing Quality Work

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Where Work Quality Problems Start

This company destroys their own equipment
1) The Technician does not understand!
2) The Supervisor does not understand!
3) The Engineer does not understand!
4) The Manager does not understand!
5) The CEO does not understand!

But they are all doing their best... how sad!

- Compressed Air??
- Cramped Space??
- Exposed Bearings??
- Wrong Gloves??
- Emery Cloth??
- Peen Hammer??
- Filthy Table??
- Polished Bore??
- Exposed Bearings??
The Table confirms that ‘human element’ error is real and **unavoidable**. We do not perform well when tasks are structured in ways that require great care and we perform especially badly under complicated, non-routine conditions. Add stress into that that mix and you get disaster.

### Human Error Rate Table


<table>
<thead>
<tr>
<th>Reason</th>
<th>Error rate (per task)</th>
<th>Read/</th>
<th>Error rate (per task)</th>
<th>Read/</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>reason</td>
<td></td>
<td>reason</td>
</tr>
<tr>
<td></td>
<td><strong>Physical</strong></td>
<td><strong>Everyday</strong></td>
<td><strong>Physical</strong></td>
<td><strong>Everyday</strong></td>
</tr>
<tr>
<td></td>
<td><strong>operation</strong></td>
<td><strong>yardstick</strong></td>
<td><strong>operation</strong></td>
<td><strong>yardstick</strong></td>
</tr>
<tr>
<td>Simplest possible task</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fail to respond to annunciator</td>
<td>0.0001</td>
<td>0.00001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overfill bath</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fail to isolate supply (electrical work)</td>
<td>0.0002</td>
<td>0.0001</td>
<td></td>
<td>0.003</td>
</tr>
<tr>
<td>Read single alphanumeric wrongly</td>
<td>0.0003</td>
<td>0.0005</td>
<td></td>
<td>0.005</td>
</tr>
<tr>
<td>Read 3-letter word with good resolution wrongly</td>
<td>0.0005</td>
<td>0.0005</td>
<td></td>
<td>0.01</td>
</tr>
<tr>
<td>Select wrong switch (with mimic diagram)</td>
<td>0.005</td>
<td>0.005</td>
<td></td>
<td>0.01</td>
</tr>
<tr>
<td>Fail to notice major cross-roads</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Routine simple task</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Read a checklist or digital display wrongly</td>
<td>0.001</td>
<td>0.001</td>
<td></td>
<td>0.01</td>
</tr>
<tr>
<td>Set switch (multi-position) wrongly</td>
<td>0.001</td>
<td>0.002</td>
<td></td>
<td>0.01</td>
</tr>
<tr>
<td>Calibrate dial by potentiometer wrongly</td>
<td>0.003</td>
<td>0.003</td>
<td></td>
<td>0.01</td>
</tr>
<tr>
<td>Check for wrong indicator in an array</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wrongly carry out visual inspection for a defined criterion (e.g. leak)</td>
<td>0.004</td>
<td>0.004</td>
<td></td>
<td>0.02</td>
</tr>
<tr>
<td>Fail to correctly replace PCB</td>
<td>0.005</td>
<td>0.005</td>
<td></td>
<td>0.02</td>
</tr>
<tr>
<td>Select wrong switch among similar</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Maintenance Error Rates

Not every error leads to failure

In failure rate terms the incident rate in a plant is likely to be in the range of $20 \times 10^{-6}$ per h (general human error) to $1 \times 10^{-6}$ per h (safety-related incident).

Source: Ledet, Winston, The Manufacturing Game

The Failure Pyramid

- **Serious Failure**: 1
- **Losses**: 10
- **Repairs (a failure)**: 6500
- **Defect Modes**: 20,000

**Routine task with care needed**
- Mate a connector wrongly: 0.01
- Fail to reset valve after some related task: 0.01
- Record information or read graph wrongly: 0.01
- Let milk boil over: 0.01
- Type or punch character wrongly: 0.01–0.03
- Do simple arithmetic wrongly: 0.02
- Wrong selection – vending machine: 0.03
- Wrongly replace a detailed part: 0.02
- Do simple algebra wrongly: 0.05
- Read 5-letter word with poor resolution wrongly: 0.06
- Put 10 digits into calculator wrongly: 0.1
- Dial 10 digits wrongly: 0.25

**Complicated non-routine task**
- Fail to notice adverse indicator when reaching for wrong switch or item: 0.1
- Fail to notice wrong position of valves: 0.5
- Fail to act correctly after 1 min in emergency situation: 0.9

**Error rate (per task)**
- **Read/reason**
- **Physical operation**
- **Everyday yardstick**
Probability of Work being Done Right

Remember this ...?
We have a series process.
One fails ... all fails! One poor ... all poor!

\[ R_{\text{job}} = R_1 \times R_2 \times ... \times R_n \]

At 10 errors/100
\[ 0.9 \times 0.9 \times 0.9 \times 0.9 \times 0.9 = 0.59 \]

At 1 error/100
\[ 0.99 \times 0.99 \times 0.99 \times 0.99 \times 0.99 = 0.95 \]
A Maintenance Job Plan

JOB PLAN TO INSTALL NEW BEARINGS IN CONVEYOR PULLEY PLUMMER BLOCKS

1. Prepare for Job in Dirt-Free Work Area
2. Safe Isolation and Handover
3. Check Parts and Materials are Correct
4. Access Plummer Blocks and Bearings
5. Check Shaft Condition and Tolerance
6. Measure Bearing Internal Clearance
7. Measure Plummer Base Plate Accuracy
8. Locate Bearings on Shaft
9. Mount Bearings on Shaft
10. Position Plummer Blocks and Place Pulley
11. Complete Plummer Block and Seals Assembly
12. Align Plummer Blocks
13. Lubricate Bearing and Seals
14. Align Plummer Blocks and Bolt Down
15. Commission and Test
16. Clean-up and Hand Back
Job Plan as a Process Flow Diagram

"One poor; all poor."
"One wrong; all wrong."
Chance of Success in a 16 Task Job Plan

Each Activity has its own Quality Distribution

\[ R_{\text{job}} = R_1 \times R_2 \times \ldots \times R_{16} \]

Final Job Quality Distribution is WIDE

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But this is a Job Plan, Not a Job Procedure
This Job Procedure has 75 Non-Routine and Complicated Activities

\[ R_{job} = R_1 \times R_2 \times \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ ld
No Job Procedure... Human Error Dominates

1. Prepare for Job in Dirt Free Work Area
2. Safe Isolation and Handover
3. Check Parts and Materials are Correct
4. Access Plummer Block and Bearings
5. Check Shaft Condition and Tolerance
6. Measure Bearing Internal Clearance
7. Measure Plumber Base Plate Accuracy
8. Locate Bearings on Shaft
9. Mount Bearings on Shaft
10. Position Plummer Blocks and Place Pulley
11. Complete Plummer Block and Seals Assembly
12. Align Plummer Blocks
13. Lubricate Bearing and Seals
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15. Commission and Test
16. Clean-up and Hand Back

TERRIBLE

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The ‘Game’ of Business

In control and capable

In control but not capable

Out of control
Carpenter’s Creed: *measure twice, cut once*

This is a ‘mistake proofing’ method that greatly reduces the chance of an error being made and left behind in a job as a defect that will later cause failure.

\[ R_{\text{parallel}} = 1 - [(1 - R_1)(1 - R_2)] \]

- 1 error every 200 opportunities ~ 1 / wk
- 1 error every 5000 opportunities ~ 1 / 20 wk
## Answers are in the Human Error Rate Table

<table>
<thead>
<tr>
<th>Simplest possible task</th>
<th>Error rate (per task)</th>
<th>Physical operation</th>
<th>Everyday yardstick</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fail to respond to annunciator</td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.00001</td>
</tr>
<tr>
<td>Overfill bath</td>
<td>0.0002</td>
<td>0.0002</td>
<td>0.0002</td>
</tr>
<tr>
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</tr>
<tr>
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<td>0.0005</td>
<td>0.0005</td>
<td>0.0005</td>
</tr>
<tr>
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<td>0.0006</td>
<td>0.0006</td>
<td>0.0006</td>
</tr>
<tr>
<td>Select wrong switch (with mimic diagram)</td>
<td>0.0007</td>
<td>0.0007</td>
<td>0.0007</td>
</tr>
<tr>
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<td>0.0008</td>
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</tr>
<tr>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Read a checklist or digital display wrongly</td>
<td>0.001</td>
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<tr>
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<td>0.003</td>
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<td>0.005</td>
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<tr>
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<td>0.005</td>
<td>0.005</td>
<td>0.005</td>
</tr>
<tr>
<td>Select wrong switch among similar</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>~5 sigma</td>
<td>0.005</td>
<td>0.005</td>
<td>0.005</td>
</tr>
<tr>
<td>Read analogue indicator wrongly</td>
<td>0.006</td>
<td>0.006</td>
<td>0.006</td>
</tr>
<tr>
<td>Read 10-digit number wrongly</td>
<td>0.007</td>
<td>0.007</td>
<td>0.007</td>
</tr>
<tr>
<td>Leave light on</td>
<td>0.008</td>
<td>0.008</td>
<td>0.008</td>
</tr>
<tr>
<td>Routine task with care needed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mate a connector wrongly</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Fail to reset valve after some related task</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Record information or read graph wrongly</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Let milk boil over</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Type or punch character wrongly</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Do simple arithmetic wrongly</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Wrong selection – vending machine</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Wrongly replace a detailed part</td>
<td>0.03</td>
<td>0.03</td>
<td>0.03</td>
</tr>
<tr>
<td>Do simple algebra wrongly</td>
<td>0.04</td>
<td>0.04</td>
<td>0.04</td>
</tr>
<tr>
<td>Read 5-letter word with poor resolution wrongly</td>
<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>Put 10 digits into calculator wrongly</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
</tr>
<tr>
<td>Dial 10 digits wrongly</td>
<td>0.07</td>
<td>0.07</td>
<td>0.07</td>
</tr>
<tr>
<td>Complicated non-routine task</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fail to notice adverse indicator when reaching for wrong switch or item</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Fail to recognize incorrect status in roving inspection</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>New workshift – fail to check hardware, unless specified</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>General (high stress)</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
</tr>
<tr>
<td>Fail to notice wrong position of valves</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Fail to act correctly after 1 min in emergency situation</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
</tr>
<tr>
<td>~4.5 sigma</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>~4 sigma</td>
<td>0.03</td>
<td>0.03</td>
<td>0.03</td>
</tr>
<tr>
<td>~2 - 3 sigma</td>
<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
</tr>
</tbody>
</table>


In failure rate terms the incident rate in a plant is likely to be in the range of $20 \times 10^{-6}$ per h (general human error) to $1 \times 10^{-6}$ per h (safety-related incident).
What is Wrong with this Job Plan?

JOB PLAN TO INSTALL NEW BEARINGS IN CONVEYOR PULLEY PLUMMER BLOCKS

1. Prepare for Job in Dirt-Free Work Area
2. Safe Isolation and Handover
3. Check Parts and Materials are Correct
4. Access Plummer Blocks and Bearings
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11. Complete Plummer Block and Seals Assembly
12. Align Plummer Blocks
13. Lubricate Bearing and Seals
14. Align Plummer Blocks and Bolt Down
15. Commission and Test
16. Clean-up and Hand Back
What is Wrong with this Inspection?

<table>
<thead>
<tr>
<th>Task List #</th>
<th>Various</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Visual Inspection of Pump**

Pump Inspected: __________

**Visual Inspection Only**

1. Check pump base - corrosion / security.
2. Check pump guards - cracked / secured / adequate.
3. Check associated pipework for support / leaks.
4. Check associated valves have handles and are in safe condition.
5. Check suction expansion joint for external wear and cracking.
6. Check condition of motor and associated cables.
7. Check condition of stop / start station.

Raise Subsequent Notification Maintenance for any repairs required.

Inspected by: __________

Date: ___/___/_____

• Roving Inspection 1:10 errors
• Defined Criteria Inspection 3:1000

**NOTE:**
None of these task will prevent the pump and piping from failing. These tasks find failure after it has happened... and you want a healthy, reliable pump set...!??
Where Shutdown Work Quality Needs to Be!

Maintenance Work Quality

Frequency of Outcome

Cost of Loss

Minimum Loss

Lower

OPTIMUM RELIABILITY

Upper

TERIBLE

TERRIFIC

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Reliability Creating 3T Error Proof Procedures

Build Mistake Proofing into your SOPs

• Set a Target for each task.
• Specify the acceptable Tolerance.
• Do a Test to prove accuracy.

Frequency of Outcome

Bands of Lesser Quality (Decreasing Value)
‘Good, Better, Best’
‘Bronze, Silver, Gold’

Quality improvement occurs when variation is reduced

Specification

Range of Possible Outcomes

Target Precision

Output

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**Develop & Use Accuracy Controlled Error Proof Procedures with Quality Standards to Meet**

One Layout for an Accuracy Controlled 3T – Target, Tolerance, Test – Failure Prevention Procedure

![Image of the layout](image-url)

<table>
<thead>
<tr>
<th>Task Step No.</th>
<th>Task Step Owner</th>
<th>Task Step Name</th>
<th>Full Description of Task</th>
<th>Test for Correctness</th>
<th>Record Actual Result</th>
<th>Action if Out of Tolerance</th>
<th>Sign-off After Complete</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td>(Include all tables, diagrams and pictures here)</td>
<td>Describe the test and below specify the target as ‘BEST’ and range of acceptable results that are ‘Good enough’:</td>
<td>Good</td>
<td>Better</td>
<td>Best</td>
</tr>
</tbody>
</table>

**Tolerance for Quality**

**Target for Precision**

**Test for Reliability**

Tell people how to fix the problem

www.lifetime-reliability.com
How 3T’s Guide Workmanship Quality

As MAGNIFICENT as it needs to be

As BAD as allowed

Perfect Result  World Class Target  Tolerance Limit  Certain Failure

BEST  BETTER  GOOD

PASS / ACCEPT  FAIL / REJECT

How close to Right is close enough?
3T’s Centre Work Quality at the Optimum

Only accept this range of outcomes because they are what we want

Error Proof Procedures Optimise Process Outcome Distribution

Maximum Loss
Minimum Loss

Work Quality

Tolerance Target Tolerance Target
Remove the Variability in How a Job is Done by Using Error Proof Techniques

By setting quality controls into a job you ensure the actions that create reliability are done thereby greatly reducing the chance that a mistake will be made.

In the end... reliability is a quality control issue because the standards you meet create the reliability you get
Do Quality Work and You are Always Sure to make Money

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