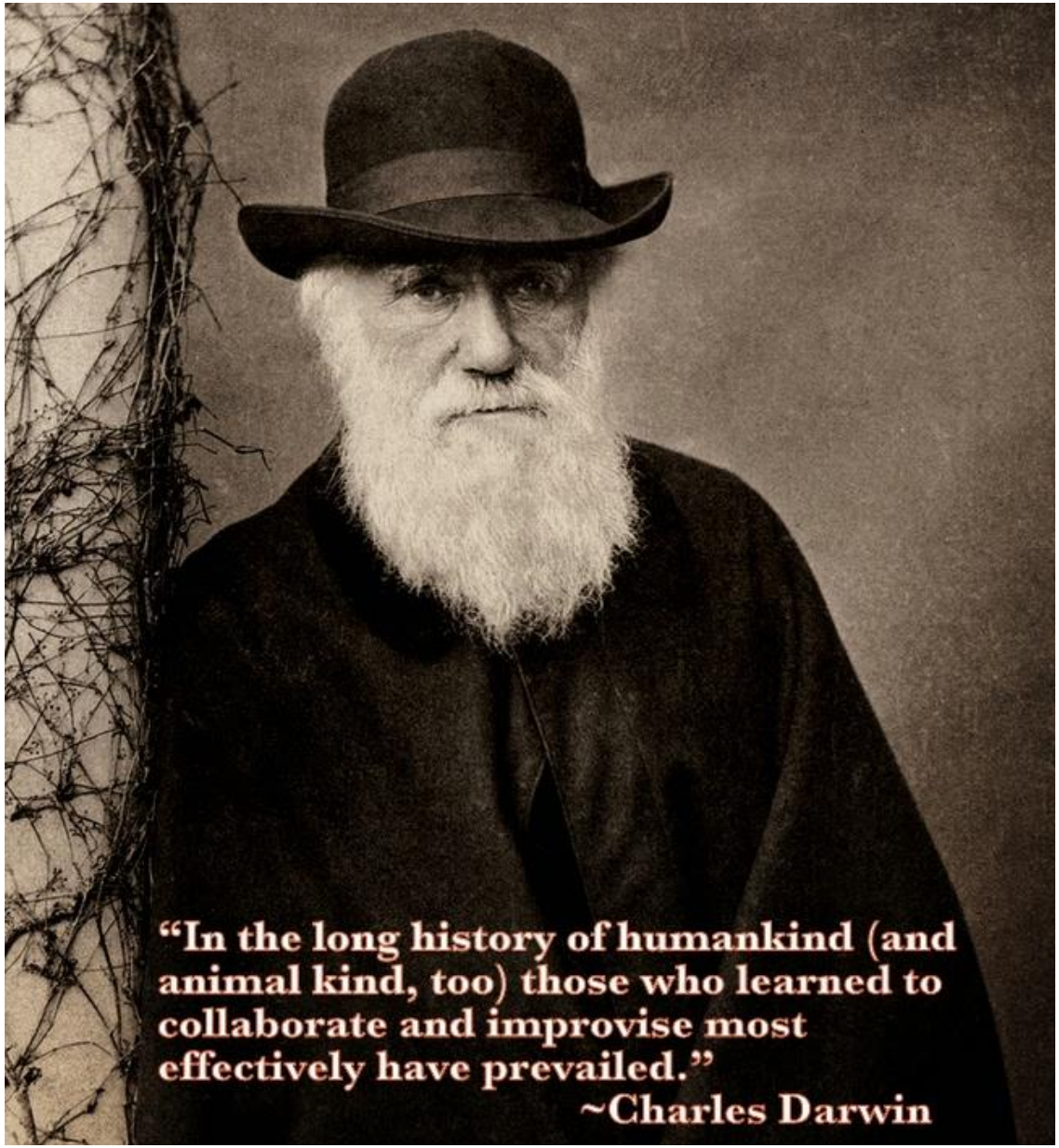
WOOD GROUP KENNY

Corrosion Engineering

‘Adding Value’ by Billy Morrison

Agenda

- **Setting the scene;**
- **Overview of Integrity Documents;**
- **Baseline Surveys;**
- **Operations;**
- **Material Selection;**
- **Questions;**
- **Summary**


"In the long history of humankind (and animal kind, too) those who learned to collaborate and improvise most effectively have prevailed."
~Charles Darwin

Dr. Heike Hoffman

SRB, Fe counts, Sulphide Counts etc.

‘ The trend is your friend’


CB*1: 43.70
Vol: 749650
120.00
110.00
100.00
90.00
80.00
70.00
60.00
50.00
43.70
40.00
30.00
2014
2015

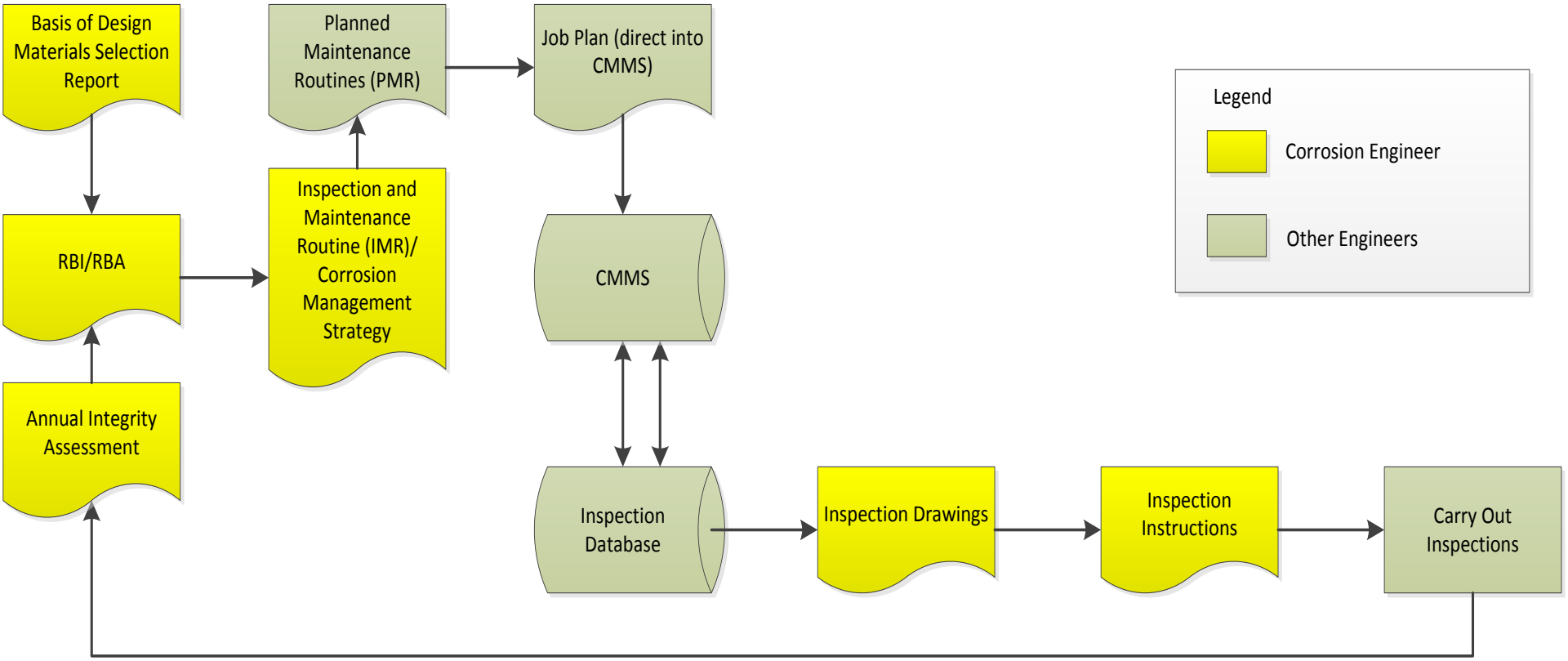
In our case, the trend is not or friend!

Used to be less $60 for a year

Even Lower for Even Longer

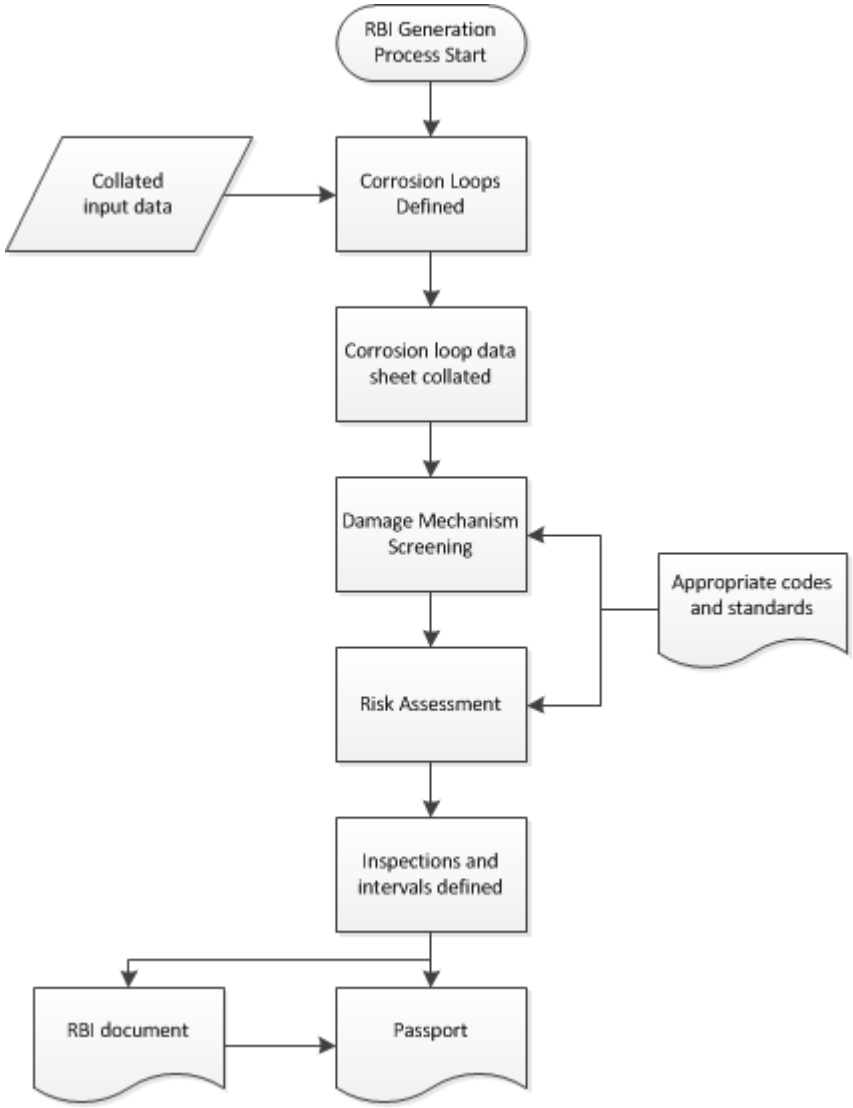
Brent Crude $43/barrel

Integrity Management Overview



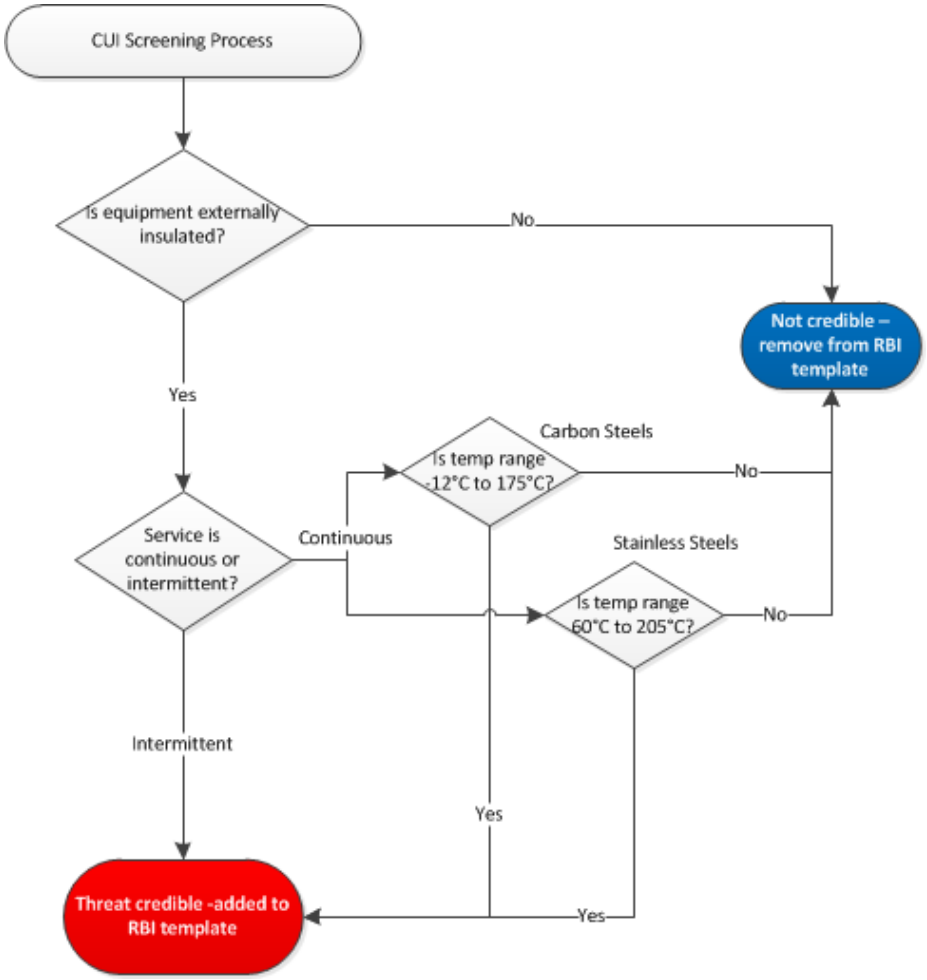
RBI Methodology

- Data Collated;
- Corrosion loops / systems defined;
- Risk Assessment Performed;
- Inspection Techniques and Intervals defined;
- Equipment WSEs/Passports produced.



Screening Tool

- **Threat credibility assessment;**
- **Based on input criteria for component, software will remove all non-credible threats.**



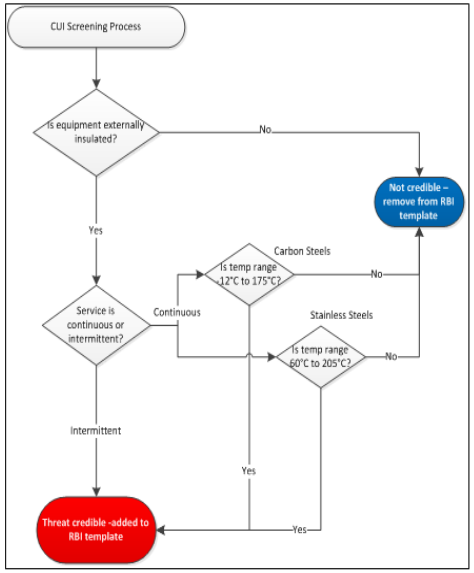
RBI/RBA Tool

System Input Parameters

Parameter	Data	Units
Material	AISI 316L	
Coating	3LPPE	
Insulation	Yes	
Within crane radius	No	
Offshore Environment	Yes	
Piping Supports present	Yes	
Dead Leg Present	No	
Adjacent to rotating equipment	Yes	
Service Type	Gas	
Service Mode	Intermittent	
Operating Temperature	15	°C
Operating Pressure	200	barg
CO_2 Content	10	ppm
O_2 Content	0	ppm
H_2S Content	30	psia
Elemental Sulpur Content	0	ppm
Organic Acid Content	15	ppm
Water Content	100	ppm
Chloride Content	0	ppm
Flow rate	15	mmscfd
Bacterial Presence	2.00E+03	cells/ml

Screening Algorithm

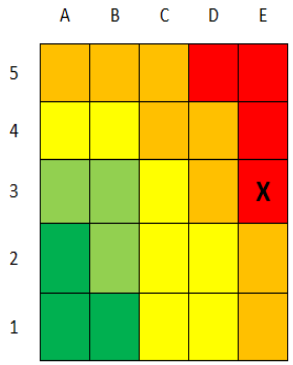
CUI



Severity Assessment Guidance

Gas export line	Topsides	Riser
Safety	5	5
Business	5	5
Environment	2	2
Governing severity	5 (S, B)	5 (S, B)
Oil export line	**Topsides**	**Riser**
Safety	4	4
Business	5	5
Environment	4	4
Governing severity	5 (B)	5 (B)
Production (infield) line	**Topsides**	**Riser**
Safety	4	4
Business	4	4
Environment	4	4
Governing severity	4 (S,B,E)	4 (S,B,E)
WI line	**Topsides**	**Riser**
Safety	4	4
Business	3	4
Environment	2	2
Governing severity	4 (S)	4 (S, B)
Gas lift line	**Topsides**	**Riser**
Safety	5	5
Business	3	4
Environment	2	2
Governing severity	5 (S)	5 (S)
Methanol line	**Topsides**	**Riser**
Safety	3	3
Business	3	4
Environment	3	3
Governing severity	3 (S,B,E)	4 (B)

Risk Level



RBI/RBA Methodology (Piping)

- Risk Assessment pro-forma completed in line with API 580 / Company Risk Policy

Corrosion Loop: NC-01-012A
Fuel Gas System
Risk Assessment

Failure Category	Threat/Failure Mode	Consequences	Component Condition	CoF				LoF	Unmitigated Risk	As-built Factors / Mitigations	LoF	Mitigated Risk	Inspection Activity	Frequency
				S	B	E	R							
Natural Hazard Threats	Extreme Weather	Dent; Crack; Coating damage; LOC.	2011 GVI reported no anomalies attributable to this failure category	1	3	3	1	4	12	Jacket is designed for extremes of environment conditions based on 50 year return.	3	9	GVI	4 yearly or on incident
Incorrect Operation Threats	Operation outside design temperature	Overstress, Embrittlement LOC.	Typical operating temperature 10-20°C with a maximum of 32.7°C in 2014. Despite the unknown maximum design temperature of the ESDV, a very low threat is present given the current operating conditions.	4	4	3	1	4	16	ESDV design temperature: Min: +4, Max: HOLD Piping design temperature: Min: HOLD, Max: +82°C Operating over-temperature alarm trips	2	8	None	Not applicable
	Operation outside design pressure		Typical operating pressure is 35barg with a maximum of 42.8barg in 2014. With the SOL and operating pressure significantly below design in this segment, a very low threat exists of overpressure.	4	4	3	1	4	16	Design pressure of ESDV: 110barg; Design pressure of piping: 149barg; SOL: 49.5barg Operating over-pressure alarm trips	2	8	None	Not applicable
	Incorrect operations		No historical operational incidents have been reported.	3	3	3	1	4	12	Covered by operational procedures	3	9	None	Not applicable
Flow Assurance	Hydrates	Hydrate blockage; Business disruption	Dew point temperature is not currently monitored. However, the same system is used as the export gas system, which adheres to export gas requirements.	1	1	1	1	4	4	Pipeline fluids conform export quality requirements.	3	3	None	Not applicable

RBI/RBA Methodology (Structures)

"A systematic overview of the installation is achieved together with a breakdown of the installations risks clearly showing the risk drivers and recommending appropriate actions." ISO 19901-9, DRAFT

Process for Asset Specific RBI

- Divide asset into Structural Critical Components;
- Determine applicable failure modes;
- Conduct situation based likelihood and consequence assessment;
- Rank component risk inline with company risk policy;
- Optimize inspection strategy in line with risk assessment.

Applicable to Topsides and Subsea Structures

Caisson Risk Assessment & Prioritisation

Caissons can be risk assessed individually and inspection targeted at caissons posing highest risk, reducing likelihood of costly intervention or unplanned shutdown.

- Probability of Failure
  - Caisson Design
  - Guide and Dead Weight Support Design
  - Pump Design
- Consequence (Importance of Use)
  - Extent of Shutdown if Caisson Unavailable
  - Anticipated Time to Repair
- Consequence (Hazard Posed)
  - Dropped Object Potential
  - Possible Outcomes / Escalation of Dropped Object Scenario

Inspection Interval Definition

- **Intervals defined based on mitigated Risk profile for the system;**
- **API 570 (piping);**
- **API 1160 (pipelines).**

Inspection Type	Inspection intervals vs risk profile (years)		
	Low	Medium	High
Topsides GVI	3	1 OR 2	0-1
Topsides WTS	5	2 OR 3	1
MPI / ECI / DPI	6	3	1
Rope access GVI	6	3	1
FMD	6	3	1
Subsea GVI / CP (ROVSV / Platform)	6	3	1

Inspection and Maintenance Routines

- Use outputs from Corrosion Risk Assessment and RBI/Passport;
- High Level Inspection and Maintenance Routines – what is to be done;
- Planned Maintenance Routines – how it is be done;
- Job Plan Pro-forma – for input to Maximo.

Brief Item Description		
Equipment Identification		E-7623 Steam Turbine Condenser
Criticality Rating	Shell	Low
	Tubes	Negligible
Safety Critical		No
Dimensions / mm		2300(ø)
P&ID		46100-200A-7
Installation Date		01/07/2009
Construction Design Code		ASME VIII Div.1 (2007 Ed. + 2009 Ad.), ISO 16812 (8th Ed. 2007)
External Material	Shell/Channel	Carbon Steel (CS)
	Tubes	MISC. Titanium
External Material Grade	Shell/Channel	SA 516 Gr 60N
	Tubes	SB 338 Gr 2
Internal Material	Shell/Tubes	None
	Channel	Carbon Steel CLAD MISC. Titanium
Internal Material Grade	Shell/Tubes	None
	Channel	SB-265 Gr1
Corrosion Allowance / mm	Shell/Channel	3.2
	Tubes	0
Insulation Type		None
Design Max. Temperature / ºC	Shell/Channel	439
	Tubes	50
Design Max. Pressure / barg	Shell/Channel	0.69
	Tubes	5
Operating Max. Temperature / ºC	Shell/Channel	60.1
	Tubes	43.5
Operating Pressure / barg	Shell/Channel	-0.81
	Tubes	2
Corrosion Loop(s)		CL119 & CL209
Categorization		

- **Automatic generation of inspection outputs from RBI/RBA;**
- **Live updates to ensure WSEs align with risk profile.**

Job Plans

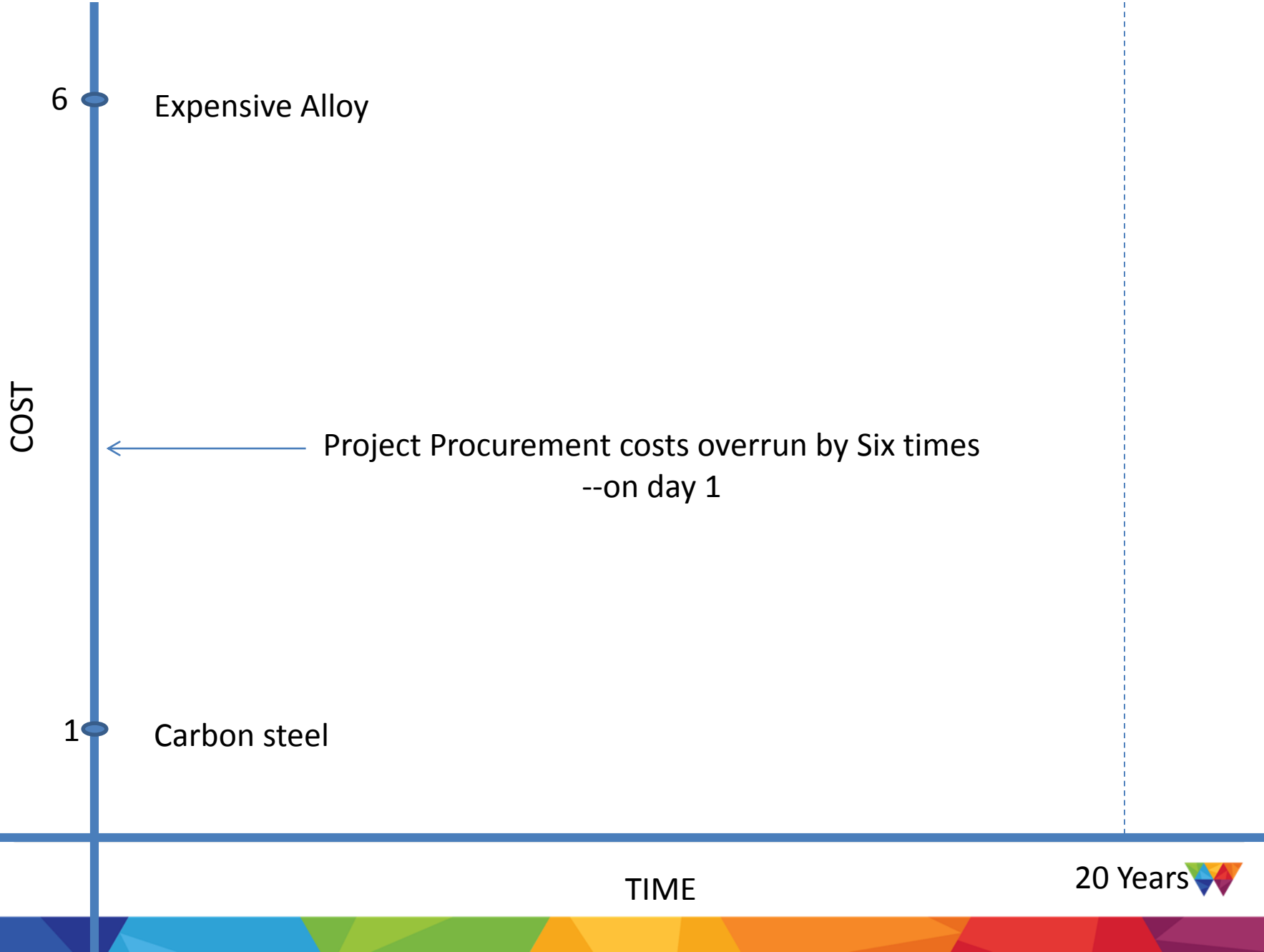
	Maintenance Category			
	Valves			
	Job Plan No.	JP-00001	*J Smith - Revision: 01*	

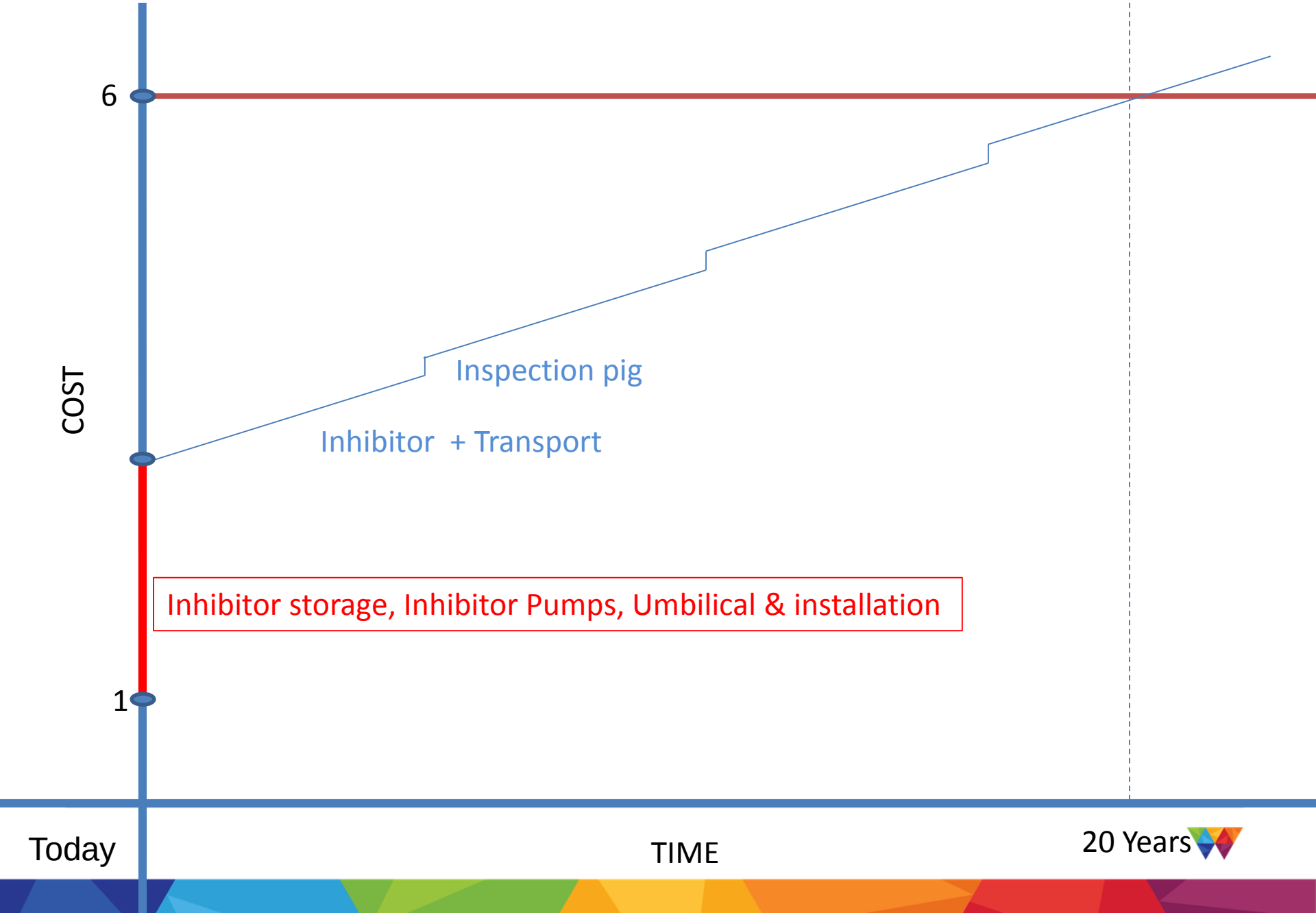
Job Plan Details					
Job Plan No.	JP-00001				
JP Description	Oil Export ESDV General Visual Inspection and Partial Closure Test		PM Description	Oil Export ESDV General Visual Inspection and Partial Closure Test	
Job Plan Part	A			Route	No
Lead Craft	OFFC-INST	**In Sequence?**	No	Hours (sum)	2
CAP	Yes	Reason	Impacts production (outages / slowdowns)		
Condition For Work	ONLINE (Work can be performed online)				
Reason For Work	PR				
Weather Dependant	No	Start Month	N/A	End Month	N/A
SCE Override	No	Reason:	Work does not affect the function of the equipment, Performance standards not affected by this task		
Basic Care	No				
Comments					

Task Details				
Identify all known tasks involved with the overall PMR. Ensure the descriptions are sufficient i.e. Erect Scaffolding for..., Isolation of..., Overhaul of..., De-isolation of..., Dismantle Scaffolding for…				
TASK	SEQ no	JP TASK DESCRIPTION	Task Duration	Nested JP
10	10	Carry out ESDV General Visual Inspection	1	

Baseline ILI Surveys

- **Barriers include QA/QC, welding procedures etc.?**
- **Why do a baseline ILI survey?**
- **Why baseline CRA pipelines?**


6
Expensive Alloy
COST
Project Procurement costs overrun by Six times
--on day 1
1
Carbon steel
TIME
20 Years


6
1
COST
Inspection pig
Inhibitor + Transport
Inhibitor storage, Inhibitor Pumps, Umbilical & installation
Today
TIME
20 Years

Gas Plant Deposits

- **Deposits found in a section of manifold pipework - chemical analysis showed deposits were, iron sulphide scales;**
- **Problem assumed to be corrosion;**
- **Program of NDT planned to locate and quantify areas of metal loss;**
- **Plan to replace sections of pipework;**
- **Need for more analysis - in particular to identify specific forms (allotropes) of scales.**

Fe[1+x]S –Mackiniwite

Most commonly found type of Iron Sulphide

Low Levels of H_2S

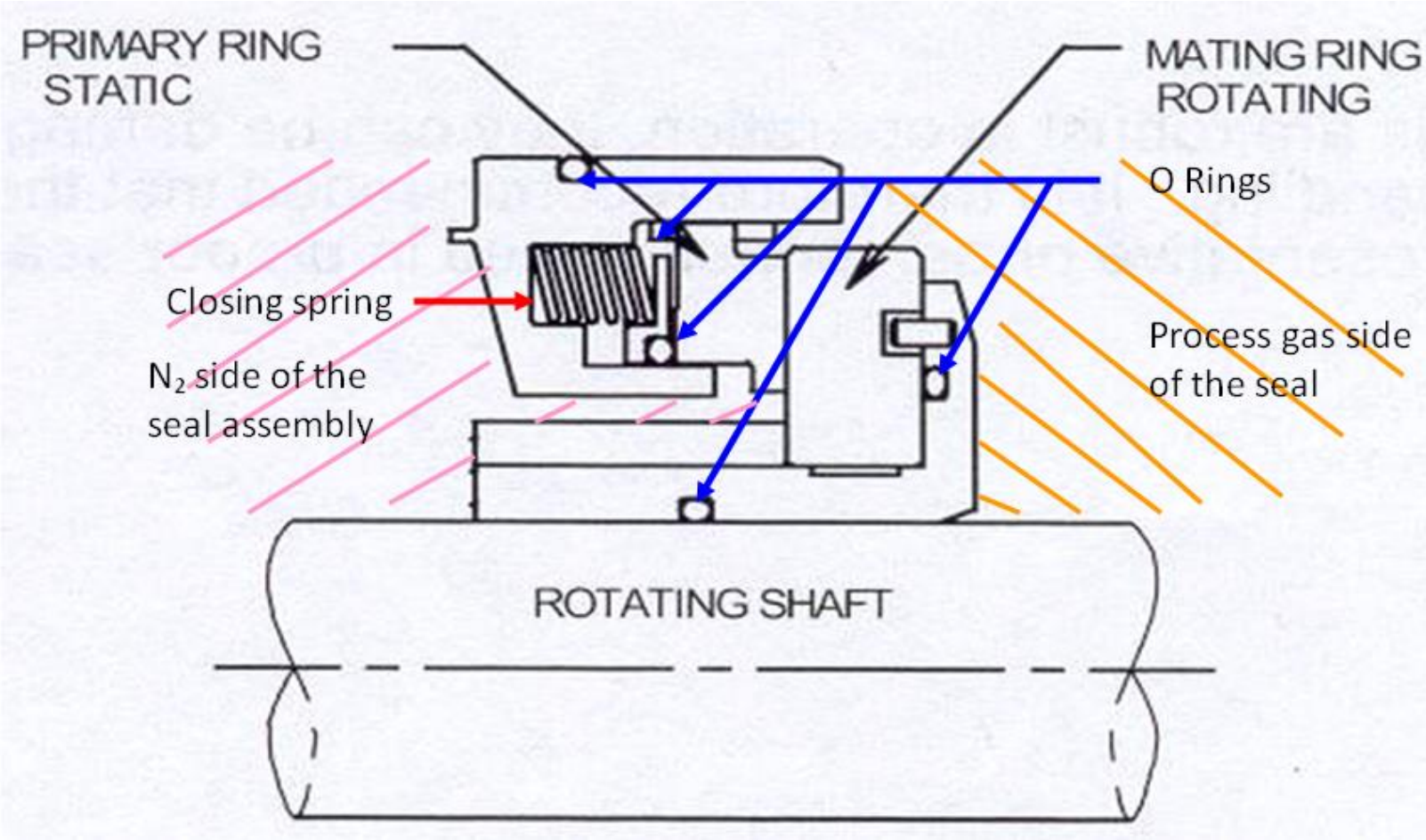
Sulphate Reducing Bacteria (SRB)

FeS_2 –Pyrite

- Mole % H_2S + low levels of Oxygen
- ½ O_2 + H_2S = H_2O + S

- **$Fe_{[1-x]}S$ – Greigite; Pyrrotite**
- Sulphate Reducing Bacteria (SRB)

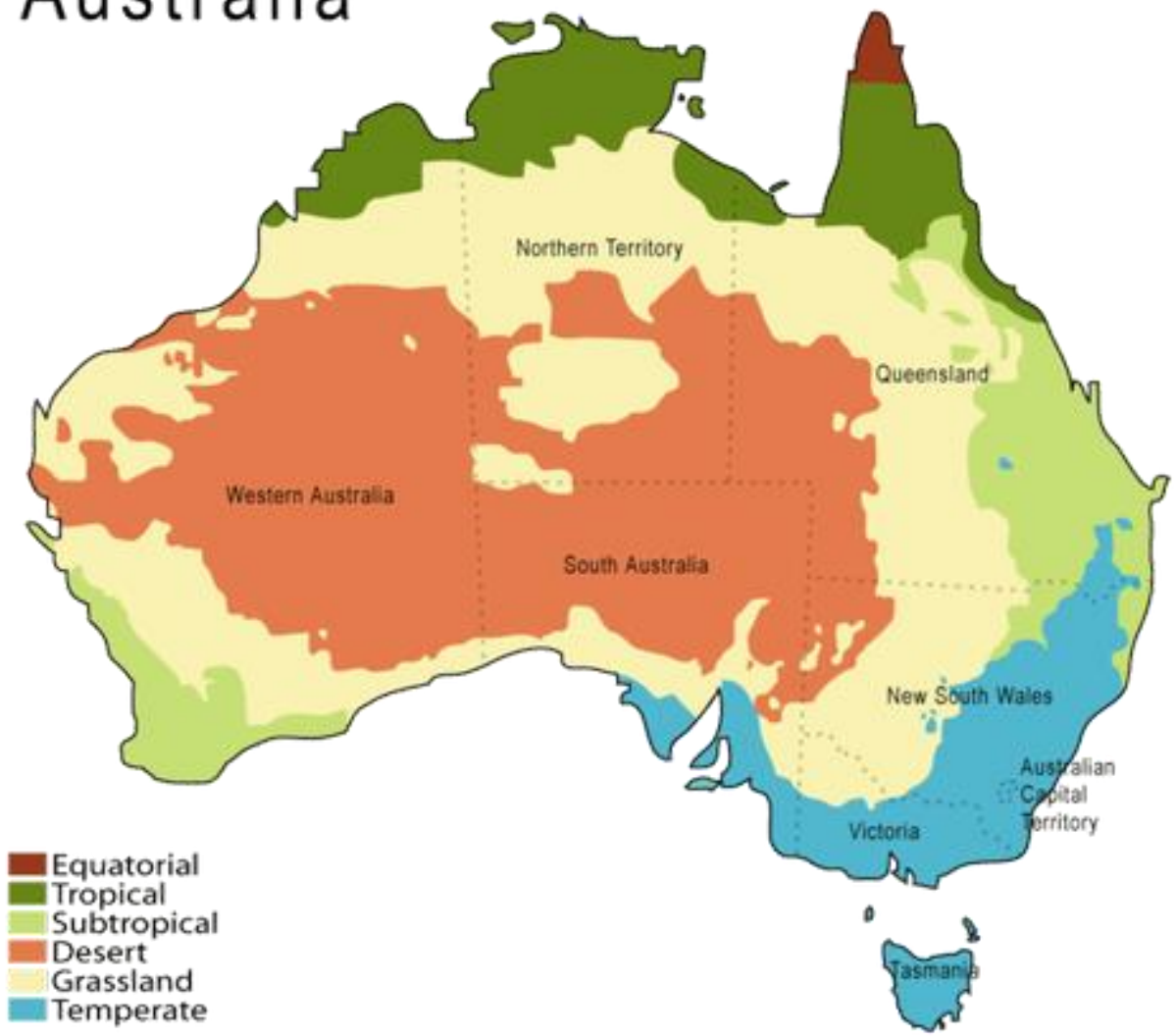
- **New Results showed deposits to be mainly pyrite;**
- **Where was oxygen coming from?**
- **Gas compressor seals likely source.**

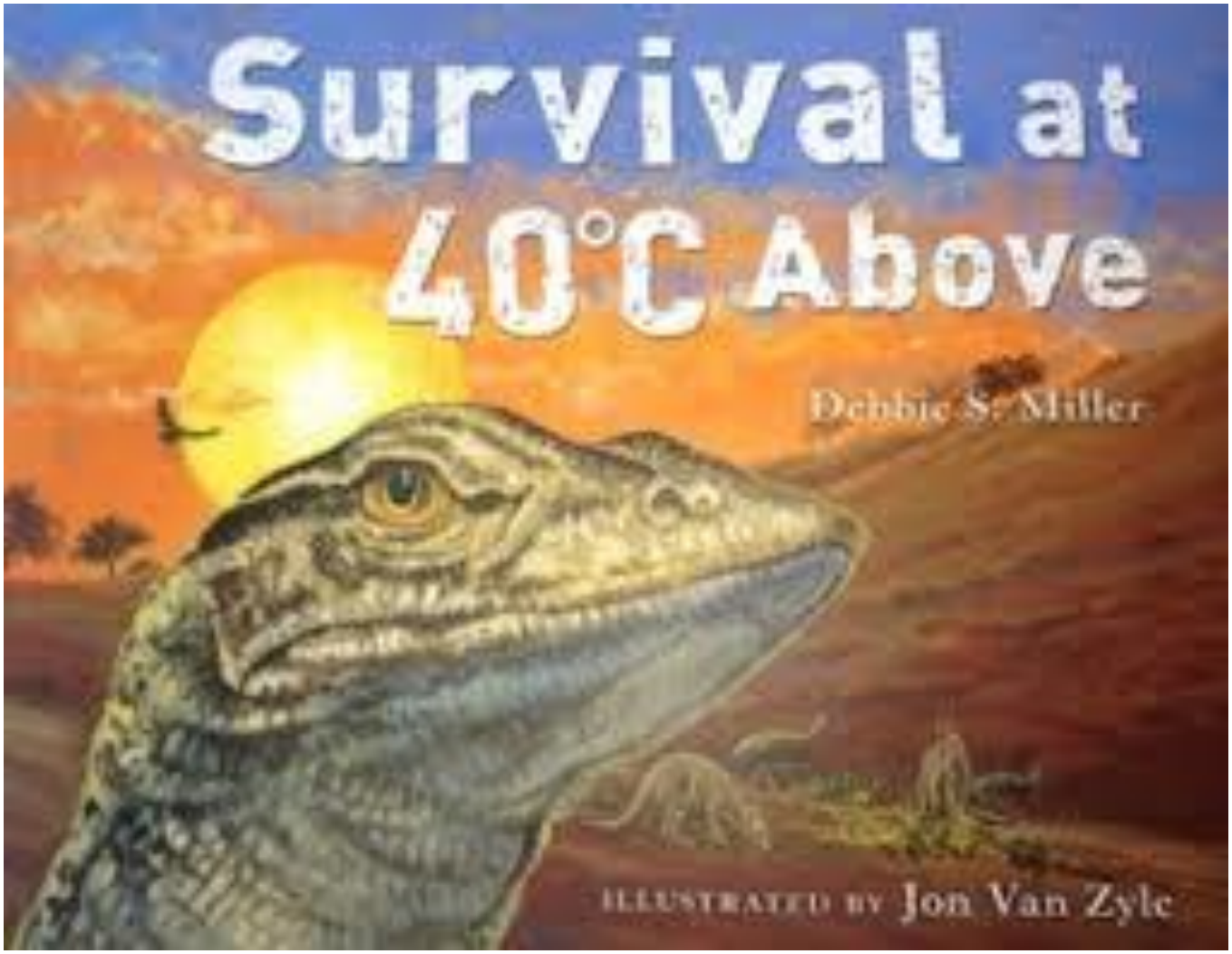

PRIMARY RING
STATIC
MATING RING
ROTATING
O Rings
Closing spring
N_2 side of the
seal assembly
Process gas side
of the seal
ROTATING SHAFT

- **Pressure Swing Adsorbers;**
- **Under pressure, gases tend to be attracted to solid surfaces, or "adsorbed“;**
- **The higher the pressure, the more gas is adsorbed; when the pressure is reduced, the gas is released, or desorbed.**

- **Problem solved by decreasing throughput which increased Nitrogen purity;**
- **Shortfall made up by using higher purity (bottled) Nitrogen;**
- **No need for NDT programme;**
- **No need for pipework replacement.**

Australia

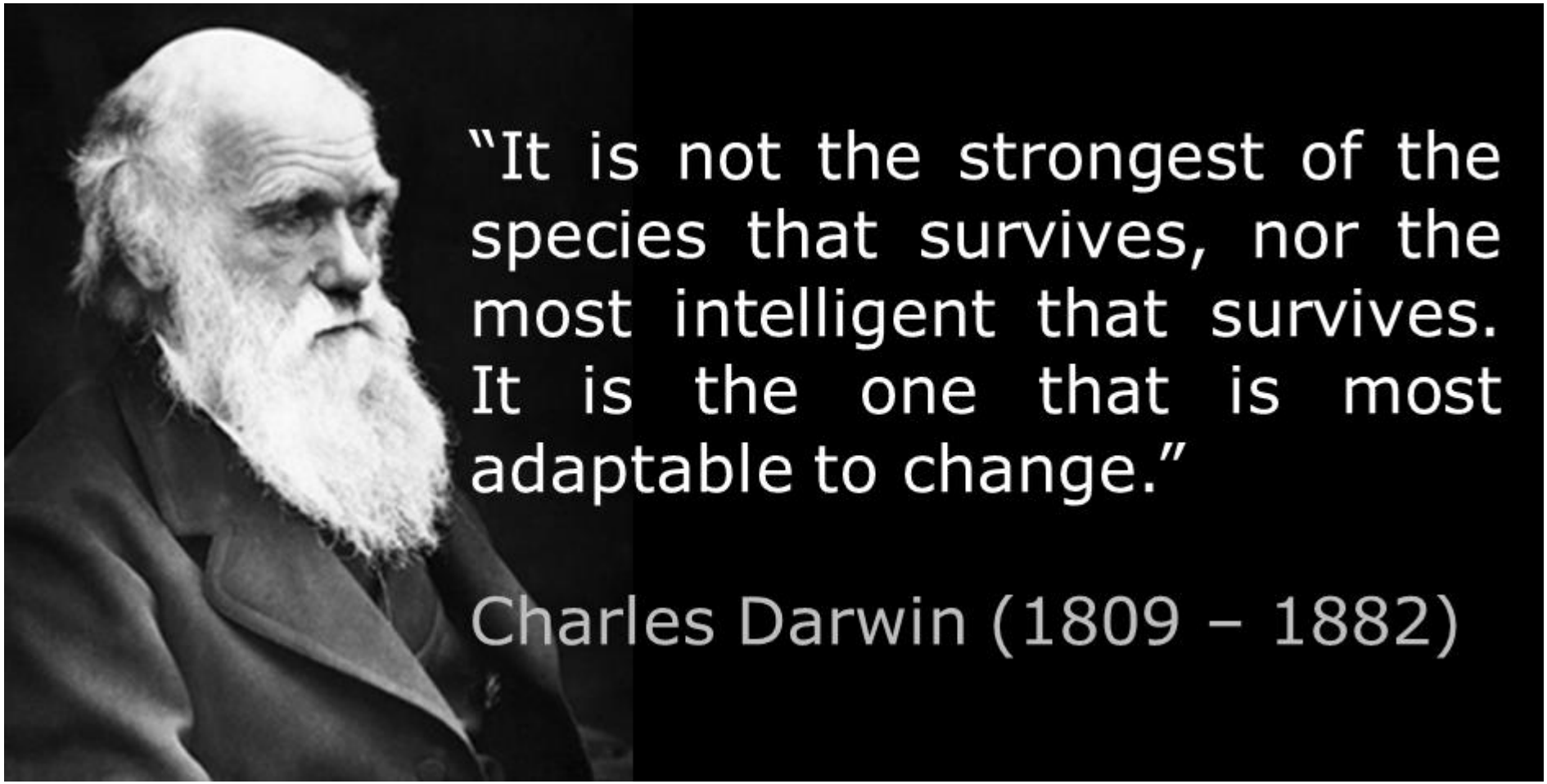

Northern Territory
Queensland
Western Australia
South Australia
New South Wales
Australian Capital Territory
Victoria
Tasmania
Equatorial
Tropical
Subtropical
Desert
Grassland
Temperate


Survival at
40°C Above
Debbie S. Miller
ILLUSTRATED BY Jon Van Zyle

- **Challenge: Survival at 40 deg C;**
- **Spec: Suitable for minus 30 deg C;**
- **Is C/S (API 5L - X52) necessary?**
- **Alternative Material; Plastic, e.g. HDPE;**
- **Benefits $$$$$;**
- **Quotation: It looks like we ‘dug up a time capsule from the 1970s and discovered a new pipe’.**

Questions

Summary


"It is not the strongest of the species that survives, nor the most intelligent that survives. It is the one that is most adaptable to change."
Charles Darwin (1809 – 1882)


THANK YOU