

Creating Procedures and Check Sheets with the Quality that Improves Reliability

Abstract

Creating Procedures and Check Sheets with the Quality that Improves Reliability. Ultimately reliability is in the hands of the people that use, build and rebuild equipment. High equipment reliability requires precision workmanship and steady, considerate operation (known as Degradation Management). Both equipment operator and equipment maintainer need to be precise, they need to know exactly what to do to always produce great reliability. Most procedures and check sheets are so poorly written that they cause equipment to be failed. Standard operating procedures can create reliability if they ensure that users meet minimum quality standards. World-class standard operating procedures set not only a minimum level of quality, they also set a highest level of quality that when achieved deliver amazing equipment reliability.

Keywords: precision maintenance, work quality standards, work quality assurance, degradation management

For a long time now I have wondered why so many companies around the world suffer poor operational equipment performance. I think back to being an apprentice fitter and machinist in the mid 1970's and the same problems that hounded us back then with our equipment condition still hound us today. I remember as an apprentice the old tradesmen telling their 'war stories' about the failures and errors which happened to them twenty and thirty years earlier. For at least 70 years that I know of, operational and maintenance errors and failures have wrecked our machines and businesses. I suspect that it has always been that way. I am now of the mind that we have serious systematic problems with the design of our businesses and business processes, and with our management, tradespeople and engineering education processes. I fear that we have created processes and systems that unintentionally, yet with certain regularity, destroy our machines and fail our businesses.

Reliability is an outcome you design and then create. You get reliability after meeting the quality requirements that produce the intended reliability. You specify the quality of engineering, manufacture, assembly, installation, operation and maintenance needed for a level of reliability. Quality is an exact number and it is measured in indisputable engineering values. It is not a happy state of mind and a nice feeling from seeing something go well. That may have happened totally by luck. There is no 'lucky' factor in creating quality and reliability. You make reliability happen intentionally – you design the business processes and practices across the life-cycle to produce it on purpose. Unless your standard operating procedures (SOPs) and check sheets contain measurable quality values that are met when the work is performed, they will destroy your machines and equipment because they work by luck instead of providing a sure way to produce high reliability.

In this article we review several common styles of standard operating procedures, record sheets and check sheets used in industry. We highlight their inherent dangers and how they can be improved to prevent the operating and maintenance disasters that they will undoubtedly cause if they are used. To address the problems and limitations caused by the example SOPs, a new style of SOP based on the Accuracy Controlled Enterprise 3T (Target-Tolerance-Test) procedure format is discussed. If you want high equipment reliability you need to make sure your managers, engineers, operators and maintainers know exactly what to do to deliver it, and can do

it exactly. You do that by installing and using only those business processes and work practices that intentionally produce the reliability you need every time they are done.

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Service Report Sheets

<p>FIELD SERVICE REPORT</p>				<p>DATE: 2 Nov 05</p>
<p>CONDITION MONITORING CHECK USING SENTINEL</p>				<p>JOB NUMBER: 5110527</p>
<p>MACHINE MODEL</p>				<p>MACHINE SERIAL No.</p>
<p>AIR END</p>		<p>GEARBOX</p>		<p>DRIVE MOTOR</p>
MDE 49/53	MNDE 47/54	INPUT N/A	DE 41/43	LUBRICANT
FDE 43/52	FNDE 47/50		NDE 44/48	SUPPLIER
				GRADE
<p>LUBRICANT</p>				
<p>CHANGED? <input checked="" type="checkbox"/> YES <input type="checkbox"/> NO SAMPLE <input type="checkbox"/> YES <input checked="" type="checkbox"/> NO</p>				
<p>MOTOR BEARINGS LUBRICATED? <input type="checkbox"/> YES <input checked="" type="checkbox"/> NO</p>				
<p>MOTOR F.L.C./VOLTAGE AT DESIGN PRESSURE</p>				
<p>GENERAL CONDITION <input checked="" type="checkbox"/> GOOD <input type="checkbox"/> FAIR <input type="checkbox"/> POOR</p>				
<p>TEMPERATURE CHECKS</p>				
<p>AMBIENT 22° DISCHARGE 73° THERMAL VALVE OPENING 763</p>				
<p>COOLER IN 5/8 COOLER OUT 27</p>				
<p>L1 / L2 / L3 /</p>				
<p>REFRIGERATED AIR DRYER</p>				
<p>GENERAL CONDITION <input type="checkbox"/> GOOD <input checked="" type="checkbox"/> FAIR <input type="checkbox"/> POOR</p>				
<p>DRYER DEW POINT 3°C CONDENSOR CLEANED/SERVICEABLE</p>				
<p>AIR RECEIVER</p>				
<p>GENERAL CONDITION <input checked="" type="checkbox"/> GOOD <input type="checkbox"/> FAIR <input type="checkbox"/> POOR</p>				
<p>TEST REQUIRED DATE SAFETY VALVE TEST DATE</p>				
<p>LEAD PRESSURE SWITCH SET POINTS IN 6.5 OUT 7.2 LAG PRESSURE SWITCH SET POINTS IN OUT</p>				
<p>REPLACED (O)</p>			<p>CHECKED AND SERVICEABLE (✓)</p>	
<p><input checked="" type="checkbox"/> INTAKE AIR FILTER</p>			<p><input checked="" type="checkbox"/> CONTROL REGULATOR</p>	
<p><input type="checkbox"/> INLET AIR FILTER</p>			<p><input checked="" type="checkbox"/> INTAKE CONTROLLER</p>	
<p><input type="checkbox"/> MAIN OIL FILTER</p>			<p><input checked="" type="checkbox"/> PRESSURE SWITCH</p>	
<p><input checked="" type="checkbox"/> BEARING OIL FILTER</p>			<p><input checked="" type="checkbox"/> BLOWDOWN VALVE</p>	
<p><input type="checkbox"/> SEPARATOR ELEMENT</p>			<p><input checked="" type="checkbox"/> MINIMUM PRESSURE VALVE</p>	
<p><input type="checkbox"/> PURGE LINE FILTER</p>			<p><input checked="" type="checkbox"/> OIL STOP VALVE</p>	
<p><input type="checkbox"/> LUBRICANT</p>			<p><input checked="" type="checkbox"/> DISCHARGE CHECK VALVE</p>	
<p><input checked="" type="checkbox"/> BELT CONDITION / TENSION</p>			<p><input checked="" type="checkbox"/> THERMOSTATIC VALVE</p>	
<p><input checked="" type="checkbox"/> BELT / DRIVE WEAR</p>			<p><input checked="" type="checkbox"/> SAFETY VALVE</p>	
<p><input checked="" type="checkbox"/> BELT / DRIVE ALIGNMENT</p>			<p><input checked="" type="checkbox"/> TUBING SECURITY / CONDITION</p>	
<p>REQUIRES FURTHER ATTENTION (X)</p>				
<p><input checked="" type="checkbox"/> ELECTRICAL CONNECTIONS</p>				
<p><input checked="" type="checkbox"/> GAUGES</p>				
<p><input checked="" type="checkbox"/> PANEL LIGHTS / INDICATORS</p>				
<p><input checked="" type="checkbox"/> AFTER COOLER</p>				
<p><input checked="" type="checkbox"/> OIL COOLER</p>				
<p><input checked="" type="checkbox"/> RECIPROCATING VALVES</p>				
<p><input checked="" type="checkbox"/> DRAIN AIR RECEIVER</p>				
<p><input checked="" type="checkbox"/> AUTO DRAINS</p>				
<p><input checked="" type="checkbox"/> MACHINE CLEANING (INT)</p>				
<p><input checked="" type="checkbox"/> MACHINE CLEANING (EXT)</p>				
<p>1. Conducted Routine major service</p>				
<p>2. Replaced items checked above</p>				
<p>3. Checked items ticked above</p>				
<p>4. Back unit for operational checks</p>				
<p>5. Conducted Vibration Analysis on air end - motor</p>				
<p>6. Air End will require oil pulley and belt, hope back next service</p>				
<p>WORKPLACE INSPECTION REQUIRED <input type="checkbox"/> YES <input checked="" type="checkbox"/> NO</p>				
<p>WORKPLACE INSPECTION COMPLETED AND ATTACHED <input type="checkbox"/> YES <input type="checkbox"/> NO</p>				
<p>CUSTOMER SUPPORT TECHNICIAN CUSTOMER REVIEW</p>				

Figure 1 - Copy of a Service Report Sheet from Air Compressor Maintenance Subcontractor

The style of service report in Figure 1 for an air compressor and air dryer inspection is common. A tick-the-box plus freehand comments method of feedback is quick and simple for the technician. Unfortunately the report contains little of value regarding the condition of the

equipment and its likely future reliability. All I can discern from the report is the technician looked at the equipment, did some overall vibration measurement, checked the machine was in a 'good-enough' condition to continue running, and left site after seeing someone to sign his time sheet. If the equipment owner kept using service reports like that of Figure 1 to monitor the machine, their air compressor will fail catastrophically before they will ever know there is something seriously wrong with it. There is no information in the report to prove the air compressor and dryer are able to continually produce quality compressed air and will deliver long-term, highly reliable operation. The better approach is to re-draft the report with clear, unambiguous descriptions and/or photographs of upper and lower acceptance limits for each item inspected. The vibration values recorded have no meaning to anyone except those that know the Sentinel Vibration Monitor System. The vibration analysis results need to be presented on a trending control chart. The vibration readings seem to be total vibration, which are no use for diagnosing bearing condition and budding reliability problems in rotating equipment.

Inspection Acceptance Forms

New/Rebuilt Motor Vibration Test Form (0- 20 HP)

Scope
This form is to used to record the shop test data taken on motors running solo in the shop.

Set up

- Motor to have a ½ key installed.
- Motor to be placed on rubber mat at least ¼" thick.
- Where possible motor to be tested at full service speed.
- Maximum line amplitude is the amplitude value of the highest discrete frequency component within the stated frequency range in any direction (HVA).
- Scope of this criteria is 2, 4, & 6 pole motors.

Equipment ID: _____

Acceptance Criteria 0-20 HP Motors		Vibration Test Data New/Rebuilt Motors				
Frequency Range	Max Line Amplitude ips pk	MOV	MIV	MOH	MIH	MIA
Sub-harmonic (< 1x RPM)	0.02					
1 x RPM	0.03					
Lower Multiples (1x RPM – 10x RPM)	0.02					
Higher Frequencies (10x – 50x RPM)	0.01					
Overall Acceleration g pk (0- 20kHz)	0.5					

Measurement locations

Side View

Top View

Figure 2 - Copy of Vibration Records of Electric Motor Baseline Vibration

Figure 2 is a baseline check sheet for a new electric motor. At first glance it seems to look the part. It has good images with clear indication of where to position the vibration detector. The vibration values are selected to detect a range of problems. My big concern is that the acceptance limits are the 'good enough' type. This really means that the performance is not yet 'bad enough' to correct. Would it not be fantastic to have another column showing world-class vibration results? Then everyone knows what superb vibration performance is and can look for ways to produce it. The one-sided acceptance limit used in Figure 2 is a trap. You only know



what ‘bad’ looks like. People using the form of Figure 2 will tend to accept motors that are just outside the limit because of the unwanted hassle and cost of getting them re-worked. The one-sided acceptance lets them think that they are saving the company money and time if the result is ‘close enough’, but in fact what they really do is bring future failures into the business. Once you create a two-sided acceptance limit that includes world-class performance, nobody can kid themselves, or anyone else, as to how the equipment is really performing. **A one-sided acceptance limit shows people how bad things can be. But a two-sided acceptance limit shows them how good things need to be to deliver world-class performance.**

Unfortunately the form in Figure 2 is designed and promoted by a world-leading maintenance consultancy. They give all their clients these forms. They teach people around the world to write forms just like Figure 2. It is a tragedy for industry. To me this explains a lot of the reason so many companies around the world have operational equipment problems. They are systematically wrecking their equipment through ignorance and misunderstanding.

Equipment Condition Inspection Forms

<u>Equipment Number</u>		<u>Work Order Number</u>		<u>Date</u>	
<u>Pump description</u>			<u>Running Hrs</u>		
<u>Machine History Checked ?</u>			<u>Clearance #</u>	<u>Isolation Points</u>	
				<u>Valves</u>	<u>Breakers</u>
<u>Pump Manufacturer</u>			<u>Pump Size</u>		
<u>Reason that Work Order was Written for Pump</u>					
<u>Inspection Section</u>					
<u>Pump Foundation & Piping</u>					
<u>Item</u>	<u>Condition</u>	<u>Bad</u>	<u>Not Checked</u>		
Grout/Foundation	Good	Bad	Not Checked		
Anchor Bolts	Good	Bad	Not Checked		
Base Condition	Good	Bad	Not Checked		
Pusher Bolts	Yes	No	Not Checked		
Suction Piping Strained	Yes	No	Not Checked		
Discharge Piping Strained	Yes	No	Not Checked		
<u>Pump Coupling</u>					
Coupling Spacer	Good	Bad	Not Checked		
Coupling Flanges	Good	Bad	Not Checked		
Coupling Hubs	Good	Bad	Not Checked		
Key Length	Good	Bad	Not Checked		
Lubricant Condition	Good	Bad	Not Checked		
<u>Pump Bowl</u>					
Impeller Rub	Yes	No	Not Checked		
Corroded/Eroded	Yes	No	Not Checked		
Gasket Leak	Yes	No	Not Checked		
Plugged in Suction/Discharge	Yes	No	Not Checked		
Wear Ring Condition	Good	Bad	Not Checked		
<u>Pump Impeller</u>					
Impeller Rub	Yes	No	Not Checked		
Corroded/Eroded	Yes	No	Not Checked		
Impeller Gasket Condition	Good	Bad	Not Checked		
Cavitation Wear	Yes	No	Not Checked		
Impeller Tips Bent/Worn	Yes	No	Not Checked		

Rear Cover			
Backplate Corroded/Eroded	Yes	No	Not Checked
Stuffing Box Corroded	Yes	No	Not Checked
Gland Gasket Leaking	Yes	No	Not Checked

Mechanical Seal			
Seal Leaking	Yes	No	Not Checked
O-rings	Good	Bad	Not Checked
Rotating Face	Good	Bad	Not Checked
Stationary Face	Good	Bad	Not Checked
Seal Flush Operational	Yes	No	Not Checked

Shaft			
Sleeve	Yes	No	Not Checked
Fretted	Yes	No	Not Checked
Grooved	Yes	No	Not Checked
Corroded/Pitted	Yes	No	Not Checked
Threads Worn	Yes	No	Not Checked
Bent/Broken	Yes	No	Not Checked

Cartridge			
Front Bearings	Good	Bad	Bearing Manuf. & #
Rear Bearings	Good	Bad	Bearing Manuf. & #
Oil Seals/Isolators	Good	Bad	
Oil Level	Good	Low	
Oil Contaminated	Yes	No	

Figure 3 - Copy of Pump Inspection and Condition Reporting Form

You see the format and content style of Figure 3 for inspecting equipment everywhere in industry. I believe it causes far more equipment failures than it prevents. My guess is that it is written by a technician with years of experience inspecting and repairing centrifugal pumps, or by a professional engineer with long years of pumps and pumping system experience. No one else could possibly hope to understand it, much less use it effectively. Like the air compressor service report of Figure 1, this form will let the pump fail catastrophically before you will ever know there is something seriously wrong with it. The reason is no one knows what 'good', 'bad', 'yes' or 'no' looks like. Such measures are entirely subjective. You must have measurable parameters to decide if a thing is, or is not, good or bad. Parameters don't move. They cannot be adjusted depending on circumstances. An inspection form needs to tell you what world-class results are for every inspection, along with what is the worst performance accepted before doing something about it. For each inspection you must know how to conduct it to ensure the test performed gives correct results and prevents bad results. Furthermore, the form must tell you exactly what to do when the performance is 'bad' in order to return it to excellent condition.

Imagine handing this work order to the typical maintenance tradesperson and telling them to do the inspections listed. Take the first inspection 'Grout/Foundation'. What could a maintenance tradesman possibly know about world-class pump base grouting and foundations? Only an experienced pump foundation and base plate design and installation engineer would know what they had to look for to decide if the pump base grout and foundation were in good or bad condition. You might be lucky and the tradesperson is highly knowledgeable in pump bases and grouting. If that happened it would be the luckiest day of your life. The same applies for every other inspection. How can you competently decide for each inspection what is 'good' and what is 'bad' when there is nothing by which you can gauge such decisions?

This form, like that of Figure 2, was designed and promoted by a world-leading equipment maintenance consultancy. They give all their clients these forms and they are teach people to write inspection forms just like Figure 3. These forms are developed with all the best of intentions, but they cause failure, because they cannot create high reliability. People will use the form and think they are providing a good maintenance service to their company and its machinery. Yet they are terribly wrong. Inspection forms without upper and lower acceptance criteria, and a repeatable proof-test to confirm the quality level, cannot deliver reliable machines.

Visual Management Based Instructions

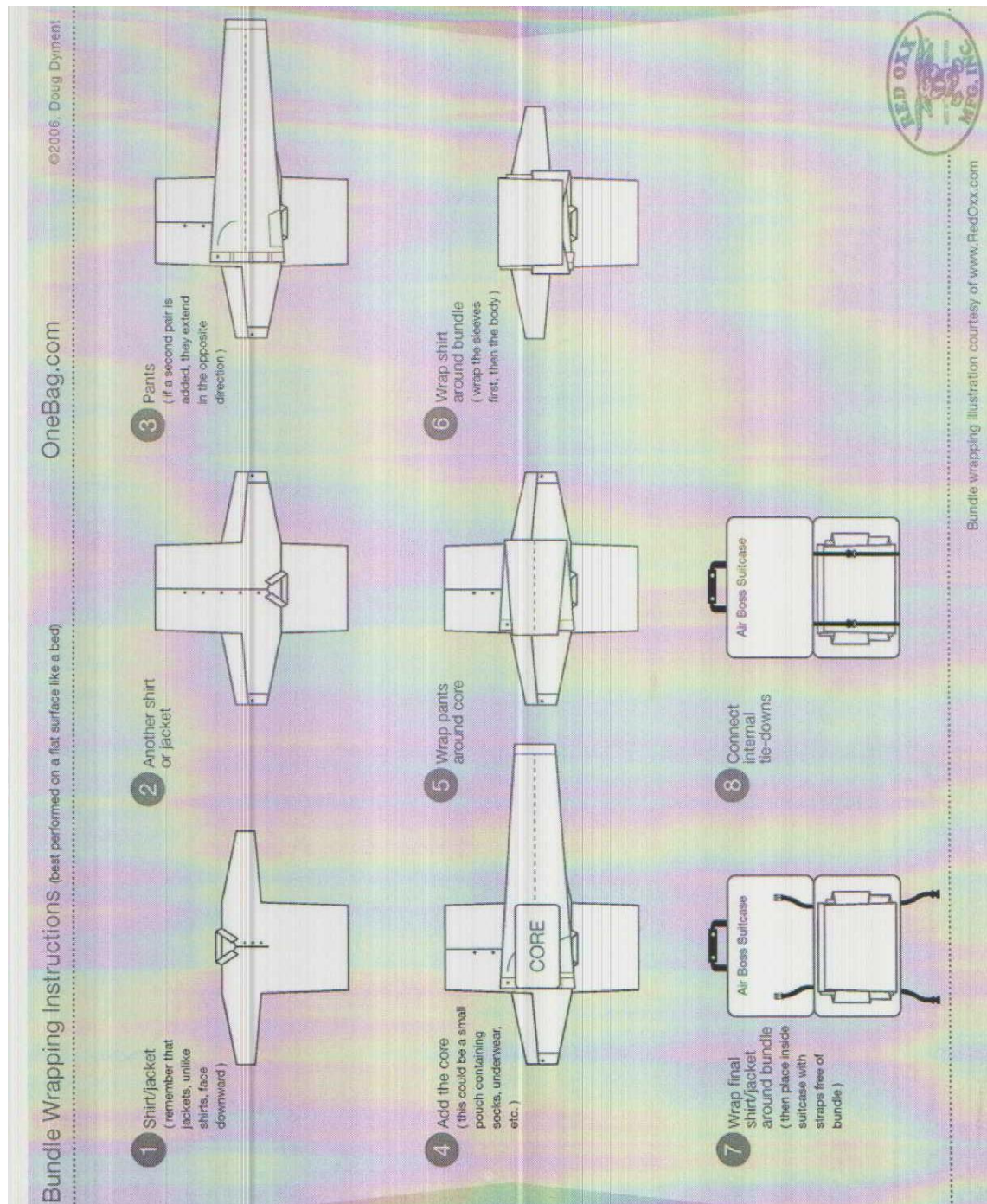


Figure 4 - Copy of Visual Instructions for Folding Clothes

Figure 4 shows how to fold clothes. It contains few words and is a great attempt to keep things simple while getting the message across. Humans get 75% of their information through their eyes. Imagine trying to explain in words what these eight pictures say on one page. You could have several pages of description and still do the folding wrong. I bet a supervisor in charge of a group using a descriptive folding procedure would be worked-off their feet explaining and showing people the right way to do the folding. A supervisor of a group using the visual procedure would take a day to train their people and then everyone would get it right. There is a trap in the visual method of 'writing' procedures. You still have to make sure people meet the



minimum standard while encouraging them to be world-class. There are no standards noted in Figure 4. There should be measurements showing upper and lower limits of location – the tolerance for positioning the clothing. I would also like to see both a top-class result and a not acceptable result shown during the training program for those people who fold clothes. **Go out of you way to provide detailed visual procedures and checklists and do not use detailed descriptive procedures and checklists.** The next example shows you why it's worth it.

Descriptive Based Acceptance Criteria

Visual Inspection Acceptance Criteria			
<u>Discontinuity Category and Inspection Criteria:</u>	Statically Loaded Nontubular Connections	Cyclically Loaded Nontubular Connections	Tubular Connections (All Loads)
(1) Crack Prohibition: Any crack shall be unacceptable, regardless of size or location.	X	X	X
(2) Weld /Base-Metal Fusion: Thorough fusion shall exist between adjacent layers of weld metal and between weld metal and base metal.	X	X	X
(3) Crater Cross Section: All craters shall be filled to provide the specified weld size, except for the ends of intermittent fillet welds outside of their effective length.	X	X	X
(4) Weld Profiles: Weld profiles shall be in conformance with 5.24.	X	X	X
(5) Time of Inspection: Visual inspection of welds in all steels may begin immediately after the completed welds have cooled to ambient temperature. Acceptance criteria for ASTM A 514, A 517 and A 709 Grade 100 and 100 W steels shall be based on visual inspection performed not less than 48 hours after completion of the weld.	X	X	X
(6) Undersized Welds: The size of a fillet weld in any continuous weld may be less than the specified nominal size (L) without correction by the following amounts (U): <div style="display: flex; justify-content: space-around;"> <div> $L,$ specified nominal weld size, in. [mm] </div> <div> $U,$ allowable decrease from L, in. [mm] </div> </div> <div style="display: flex; justify-content: space-around;"> <div> $\leq 3/16$ [5] $1/4$ [6] $\geq 5/16$ [8] </div> <div> $\leq 1/16$ [2] $\leq 3/32$ [2.5] $\leq 1/8$ [3] </div> </div> In all cases, the undersize portion of the weld shall not exceed 10% of the weld length. On web-to-flange welds on girders, undercut shall be prohibited at the ends for a length equal to twice the width of the flange.	X	X	X
(7) Undercut: (a) For material less than 1 in. [25mm] thick, undercut shall not exceed 1/32 in. [1mm], with the following exception: undercut shall not exceed 1/16 in. [2mm] for any accumulated length up to 2 in. [50mm] in any 12 in. [300mm]. For material equal to or greater than 1 in. thick, undercut shall not exceed 1/16 in. [2mm] for any length of weld. (b) In primary members, undercut shall be no more than 0.01 in. [0.25] deep when the weld is transverse to tensile stress under any design loading condition. Undercut shall be no more than 1/32 in. [1mm] deep for all other cases.	X		
(8) Porosity: (a) CJP groove welds in butt joints transverse to the direction of computed tensile stress shall have no visible piping porosity. For all other groove welds and for fillet welds, the sum of the visible piping porosity 1/32 in. [1mm] or greater in diameter shall not exceed 3/8 in. [10mm] in any linear inch of weld and shall not exceed 3/4 in. [20mm] in any 12 in. [300mm] length of weld. (b) The frequency of piping porosity in fillet welds shall not exceed one in each 4 in. [100mm] of weld length and the maximum diameter shall not exceed 3/32 in. [2.5mm]. Exception: for fillet welds connecting stiffeners to web, the sum of the diameters of piping porosity shall not exceed 3/8 in. [10mm] in any linear inch of weld and shall not exceed 3/4 in. [20mm] in any 12 in. [300mm] length of weld. (c) CJP groove welds in butt joints transverse to the direction of computed tensile stress shall have no piping porosity. For all other groove welds, the frequency of piping porosity shall not exceed one in 4 in. [100mm] of length and the maximum diameter shall not exceed 3/32 in. [2.5mm]	X		
		X	X
		X	X

*General Note: An "X" indicates applicability for the connection type.
A shaded area indicates non-applicability.*

Figure 5 - Copy of Welding Acceptance Inspection Criteria

The weld acceptance criteria in Figure 5 are correct in detail and content. But it is so full of confusing text and convoluted explanations that you must be a welding expert to understand

them. You could say that only welding experts should be doing structural welding acceptance anyway. You would be right. But the written criteria in Figure 5 are a lot of hard work to fathom and nearly impossible to understand. If you were in a hurry you'd almost certainly mistake what was contained in the words. It would be far better if these written criteria were turned into pictures and drawings of exactly what 'pass' and 'fail' looked like. That's a lot of extra work, people would say. I know. But how else do you stop errors and rework – hope they don't happen? The images of pass-fail criteria are not for the Inspector. The images are for the managers in charge of the welding, and for people doing the welding, so that they can get a great weld every time. It is not the Inspector that needs educating on weld quality; it is the welders who make the weld, and those others responsible for their work, that need to know what is, and is not, an acceptable quality. By using images instead of text there is a much greater chance that there will be no welding errors for the Inspector to find.

Inspection and Test Plans

INSPECTION AND TEST PLAN									
Drawing No.: 129D		Rev:		Customer:		WO No.:		ISO 9001:2000	
DESCRIPTION		Compression		QA STANDARD		Verification By:		Records	
No.	Inspection & Test	Applicable Specification	Inspection Points	Reference Documentation	Date	Sub-contractor			
1.	Profile Material ▪ Profile Operator to record Plate details as plate is cut.	434D 373D	In Process	5.2			M001	Cutting Details	
2.	Plate Preparation ▪ Items to be pressed ▪ Preparation of items	785D							
3.	Fit and tack fabrication – verify before final welding	785D	In Process	5.1			1005	Dimensional Check	
4.	Weld Fabrication - Dimensional check on centre to centre front/back bores.	785D	In Process				1004	Dimensional Check	
5.	100% Visual Inspection	785D	On completion of welding	5.12					
6.	Surface Treatment	Class 2.5 Blast, Prime Coat.	On completion of stamping					Paint Certification	
7.	Machine and facing of bores	129D	In Process					Machine Inspection Record	
8.	Weld of supports to Assembly	785D	In Process				1007	Weld Dimensional	
9.	Fit Bushes	129D	On completion					030 Final	

LEGEND: H= HOLD W=WITNESS S= INSPECTION

Revision 2

Date:

Page 1 of 2

Figure 6 - Copy of Page 1 of Welded Structure Quality Inspection and Test Plan (ITP)

INSPECTION AND TEST PLAN									
Drawing No.: 129D		Rev:		Customer:		WO No.:		ISO 9001:2000	
DESCRIPTION		Compression Operation/ Inspection & Test		Applicable Specification		Inspection Points		Reference Documentation	
No.									
10.	ID Stamped			Process		of machining			Inspection for Fitting Bushes
11.	Final Inspection			85D		On completion			1008 Inspection Report
12.	Documentation completed			QA Documentation completed		On Completion	5.12		Work Order File
13.	Dispatch as part of Gantry Assy			As per Purchase Order		Prior to closing Work Order			
						On completion			

LEGEND: H= HOLD W=WITNESS S= INSPECTION

Revision 2

Date:

Page 2 of 2

Figure 7 - Copy of Page 2 of Welded Structure Quality Inspection and Test Plan (ITP)

An Inspection and Test Plan lists the quality requirements and the compliance tests that must be met for acceptance. It is the plan for collecting the evidence that all the work needed to make a thing has been done right. ITPs have been used for a long time. They are part of any quality managed organisation. Though they have been used for a long time for quality management they are not successful in preventing failures. The drawback with ITPs is that they are a feedback device. You are only required to inspect after the task is completed. You do the entire job first and then you check if you did it right. That seems crazy to me. Imagine working a whole week on a job and you only find out on Friday that you made a mistake on Monday. Feedback management and reporting is only useful for learning about mistakes, not for preventing them. To prevent errors and mistakes you need feed-forward measurement and reporting.

Accuracy Controlled SOPs

A feed-forward driven SOP would tell you immediately that you have done the task right or you have made a mistake. It makes you aware of an error and lets you correct it to the required standard before doing the next task in the job. To develop a reliability-building feed-forward SOP you need a world-class standard to hit and an idea of how close to the standard you need to be to still meet minimum quality. The upper and lower quality standards form 'boundaries of excellence'. A proof-test confirms that the work produced acceptable quality. If the test shows the work is not within the quality boundary you fix it immediately and do not leave a defect. In this way all work is perfect because it always meets the necessary quality standard at every step of every task. When you write SOPs with each task given a Target, Tolerance and Test you create an Accuracy Controlled Enterprise (ACE) 3T procedure.

Figure 8 shows the upper and the lower quality limit for rotating equipment shaft alignment. It comes from John Piotrowski's 'Shaft Alignment Handbook'. It is the ideal input into an ACE 3T procedure because in one graph it provides the world-class quality target to strive for and the least acceptable result allowed. In the one chart you are given the 'Target' and the 'Tolerance' for high quality shaft alignment. The 'Test' is to measure the alignment with laser equipment (or reverse dial indicator) to prove the shaft alignment indeed meets the required quality standard. Including this two-sided acceptance standard into a shaft alignment procedure requires people to do the quality of alignment that brings with it high equipment reliability.

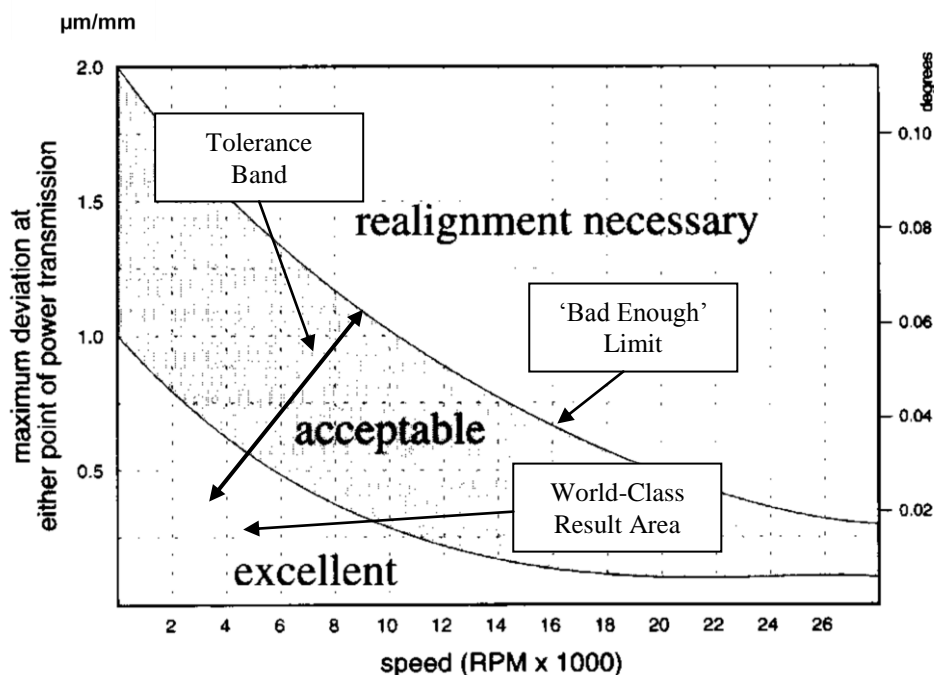


Figure 8 - Copy of Recommended Maximum Misalignment of Flexibly Connected Rotating Machinery – Shaft Alignment Handbook by John Piotrowski, CRC Press

Piotrowski's shaft alignment 'chart of excellence' makes clear what acceptable quality for rotating shaft alignment is. Once the specific values for the power transmission point deviation and angular misalignment at a given RPM are transferred into your procedures, they lock shaft alignment quality into place throughout the operation. No other standard is acceptable. Such ACE 3T procedure content says to everyone that this company wants only top-class results and anything less needs to be improved. Then you train your people how to do the job exactly right.