

## Chapter 25: Plant Wellness Audit Index

You can achieve world-class plant and machinery reliability as sure as night follows day. Getting outstanding reliability is a formulaic engineering outcome. Equipment reliability is totally dependent on component reliability (except for sabotage and acts of God), which can be fully specified by measurable engineering criteria. This makes the achievement of world-class plant reliability completely definable, as every part's necessary health conditions can be fully specified by measurable parameters. How well your business processes achieve the requirements for world-class reliability is an indicator of its effectiveness in producing highly reliable operating assets.

The results of business and workplace practice are seen in the historical evidence kept by a company. By comparing what a company does with its engineering, operations, and maintenance processes to what really creates equipment reliability, you can identify why an operation gets the plant availability it does and report with certainty on what must be changed and how to make the change to guarantee world class production performance.

### Potential for World-Class Reliability

The Plant Wellness Way uses two indexes to focus your organization on how to achieve a world-class life-cycle asset management and create outstanding reliability.

The quickest measure for gauging an operation's potential to deliver world-class reliability is the Reliability Health Capability Index, shown in Table 25.1. Within two minutes, you'll know whether your organization has what it takes to achieve world-class reliability performance. It measures the reliability creation capability of an organization. The index comprises five factors—

Processes, Quality Standards, Competence, Discipline, and Continuous Improvement—each with three measures to gauge a company’s proficiency in creating and sustaining plant and equipment reliability. They are challenging and unforgiving requirements, and the insights gained during the assessment will give you correct guidance. You want to have an index score of 8 or better. A score below 5 is life threatening.

<b>Reliability Health Capability Index</b>			
<b>Criteria</b>	<b>Description</b>	<b>Grade</b>	
Processes	Procedures and methods specifying the best way to produce all required outcomes are available	No/few documented processes, with reliance on use of human mind and memory	0
		Complete process maps with procedures for all processes, plus work instructions for critical factors	1
		Fully flowcharted, instructed in all procedural detail, and error-proofed to prevent critical step failure	2
Quality Standards	Clear criteria defining top-class outcomes, with acceptable and unacceptable results at critical points in all processes	No/few specified work quality outcomes, with reliance on human opinion for decision making	0
		Measurable quality standards set and monitored for all critical outcomes	1
		3T quality standards set, monitored, and trended for all critical process step outcomes	2
Competence	Personnel are statistically capable in all they do, with technical and emotional skills to achieve the quality standards	Qualified and trained personnel used in key positions	0
		People competent and proven capable in the role used in key positions	1
		People competent, proven capable in the role, and accomplished in the processes used in all positions	2
Discipline	Best available procedures are correctly followed by everyone throughout the organization	Most work is done as considered best by the person doing it	0
		All work is done to defined, documented instructions	1

		All work is done precisely to meet specific quality outcomes	2
Continuous Improvement	Continuously looking for, scientifically testing, and implementing better solutions	No specified or irregularly applied reliability improvement process in use	0
		Regular measuring and reporting of key process indicators and failures to identify opportunities and then doing improvements	1
		Continuous trending of process distributions and analysis of cause and effect to proactively make changes that get best results	2
		<b>TOTAL</b>	

Table 25.1—Reliability Health Capability Index

### Organizational Capability to Have High Reliability

The second index used in the Plant Wellness Way gauges the ability of your life-cycle asset management system to produce world-class plant and equipment reliability. Your operation is audited and graded based on how well its processes delivery outstanding reliability, maintenance, and operational performance. The index comprises six criteria: Least Stress in Parts, Systematic Success, On the Same Mission, Right Information, Role Competence, and Defect Elimination. The index value for each criterion is placed on the target board in Figure 25.1 to show how closely the organization’s practices come to excellence. The criteria reflect their importance in the Plant Wellness Way methodology for achieving long-lived, highly reliable equipment. Assessments are made for each category of relevant skills, practices, techniques, and solutions that bring reliability success. Audit results by category are listed in worksheets that are used to assess the tell-tale signs exhibited by an operation.

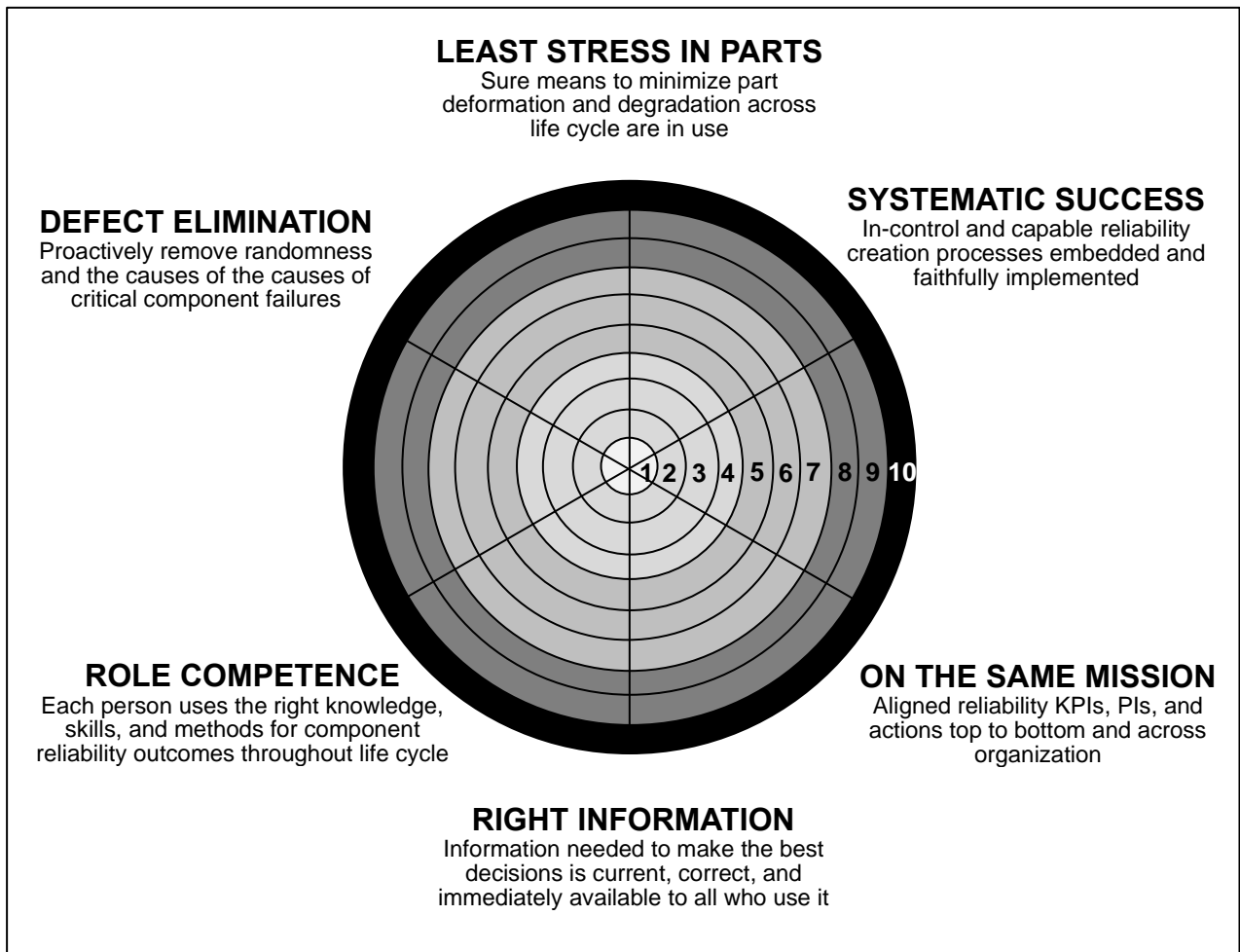


Figure 25.1—Targeted Plant Wellness Way Index

The Plant Wellness Index (PWI) is a holistic, fact-driven enterprise asset management system assessment that assigns ratings from 1 to 10, where 1 = Excellent, 2–4 = Satisfactory, 5–7 = Poor, 8–9 = Very Poor, and 10 = Failed. The meaning of each rating is explained in Table 25.2. The higher you score, the greater the variability in your life-cycle asset management processes.<sup>1</sup>

The PWI measures how well a company controls the risk hierarchy introduced in Chapter 11, extending from the Physics of Failure mechanisms impacting component microstructure health to the failure of equipment and eventual harm to the business. Once you move away from excellence, the hierarchy value representing the severity of the risks that you carry increases from 1 to 10. As you move up the hierarchy from mechanism to organization, the number of available

measurements for an asset decreases and they become less refined indicators of what is driving an asset’s operating condition. At any time, there can be multiple risks present, but you will see them less clearly as you go further up the hierarchy. If you use historical indicators of business performance, you will only see the effect of the final failure and never its multiple causes. To prevent the causes of asset failure, you need to measure and control how well the organization operates at the Physics of Failure mechanism level of component health.

<b>PLANT WELLNESS INDEX KEY</b>			
<b>Criteria</b>	<b>Condition</b>	<b>Description</b>	<b>Activity/Action</b>
	Cannot be monitored	The factor cannot be monitored for assessment,	Note why in comment column. If not rectifiable, use 10.
1	Good	All required outcomes are delivered well inside specification most effectively and efficiently. Exactly what the right thing to do is clear, and there is a clear and correct explanation of the proper way it is to be done right the first time, and it is done that way.	Copy these best practices across the organization.
2	Satisfactory – Top	All aspects are operating well within specification, and there is a long history of controlled and capable outcomes.	Copy these best practices across the organization.
3	Satisfactory	All aspects are operating within specification with no significant problem indications.	No action
4	Satisfactory – Low	All aspects are operating within specification, but there are future problem indications.	Plan for pre-emptive response. Continue to monitor event initiators.
5	Poor – Top	There is a possibility of problem(s) adversely impacting the required outcome(s).	Start pre-emptive response. Monitor event initiators with higher frequency to observe for rapid worsening.
6	Poor	Existence of a problem is self-evident.	Rectify the problem. Department manager reviews all relevant processes for weaknesses that allowed the problem to arise and undertakes process improvement(s) until weaknesses are prevented.
7	Poor – Low	Problem is adversely affecting the outcome(s).	Too late, should never have gotten this bad. Do as per 6, but manager extends resources to use of an expert team. Undertake retraining of all involved in the correct standards and practices to be used.
8	Very Poor – Top	Problem prevented outcome(s) from meeting requirements.	Too late, should never have gotten this bad. Department manager, their senior manager and expert team redesign the process(es) to eliminate causes initiating the problem. Institute necessary capital expenditure and personnel and/or supply chain training.
9	Very Poor – Low	Problem destroyed any chance of delivering the required outcome(s).	Too late, should never have gotten this bad. Do as per 8.
10	Failed	Required outcome(s) is unachievable by this approach.	Too late, should never have gotten this bad. Do as per 8.
Notes:			
a. The key is used to rate the adequacy of the response to each of the requirements noted in the audit worksheets.			
b. Only real evidence specific to the operation being audited is acceptable proof of the existence of a requirement.			

Table 25.2—Plant Wellness Index Interpretation

When trying to change from traditional failure-based maintenance, the PWI naturally moves people toward a wellness strategy and the necessary parts health and work quality practices. The PWI grading of an organization's capability to achieve world-class reliability investigates whether its processes and practices focus on doing right things and delivering the right outcomes to cause lasting component reliability.

There is a complex but predictable hierarchy of cause-and-effect failure processes traceable to the initial loss of part integrity. A misaligned shaft leads to roller bearing component overload, which leads to lubrication film breakdown, then to high metallic surface stress from metal-to-metal contact, then to bearing spalling and wear particles, and then to the bearing's collapse, which finally causes the equipment failure that stopped the plant.

The PWI numbers do not describe the health of equipment or even the health of a component but rather the ability of an operation to manage and control the precision of the quality results that deliver high reliability to parts, such as lubrication condition, alignment, unbalance, operational forces, distortion, and so on. It is a measure of the willingness of an organization to live with escalating risks of failure.

An assessment of "Very Poor" does not mean that equipment breakdown is imminent; rather, the extent of control over a quality parameter permits defects at the component level that will cause the parent equipment to fail in the future. When the assessment of a function is "Failed," the component is still likely operating, but a breakdown is sure to happen because the organization's processes didn't even identify a serious problem. In such cases, the timing of

equipment failure depends on the severity of microstructure stresses and the rate of atomic structure degradation suffered by the component in operation.

By assessing the degree of control, a company has over equipment POF factors and the development of life cycle failure cause mechanisms, you can gauge its ability to create outstanding plant and equipment reliability. Instead of using condition monitoring to observe failure modes from initiated failures and reporting their growing severity as the primary indicator of health, the Plant Wellness Index measures your asset management system's ability to instigate and sustain the causes of excellent microstructure strength and health for all critical components.

By making such information readily available across the organization, equipment users and maintainers know how to change their operating and maintenance practices to cause high reliability. Precision alignment becomes the norm because keeping shafts precisely aligned minimizes the stress suffered by the lubricant and the bearing surfaces. After a while, people start to talk about the engineering numbers that create outstanding reliability, and soon after that, everyone learns how to deliver them to their plant and equipment.

When reliability increases, the operation is seen in the new light of brightening success as the number of outages falls, the associated costs fall, safety incidents markedly decrease, and, most important of all for business success, operating profitability rapidly increases.

The use of the PWI makes it relatively easy and straight forward to assess and display the risks associated with plant ownership, which, in turn, makes the relationship between the organization and its statutory regulators more amenable because it provides the company with

clear evidence that its processes monitor and control asset health in the rare event that there is an incident.

The appropriate audit values are selected following site observation and a review of historic records of the equipment, process, and system risks. For example, in an operation that has above-design pressure events in a high-pressure gas system, the stresses on all control valve shaft seals, isolation valve internals, instruments and pipe flanges increase the chance of a leak from all items put under extra pressure. The lack of operational control will immediately result in a surge in the piping system risk. The evidence in the operating records of continued lack of control over operating pressure rates as “Poor” on the PWI for both Least Stress in Parts, and because stress increases with every high-pressure event, also for Systematic Success, since the associated risks of loss of production, environmental damage, and harm to personnel were allowed to repeat. The repetitive over pressure events indicate a business system failure and the inability to sustain reliable, safe production. When the problem is resolved, the PWI values revert to their normal status. The records will show the historical PWI values for reference, which will be used as evidence of lack (or not) of process control for regulatory reporting, business performance monitoring, and auditing requirements.

The Plant Wellness Index provides a means for prioritizing risk elimination and control, connecting the mechanisms that affect component microstructure to asset life-cycle success and business profitability. When an asset is perfectly healthy with its assemblies and parts at least stress right down to Physics of Failure level, it is at its lowest risk condition. In this state, asset failure becomes rare because there are few opportunities to cause degradation and deformation. At this level of performance, a company generates exceptional operating profit month after month, year after year.



## FOOTNOTES

1. Thank you to Paul B. Price, Reliability Consultant and Condition Monitoring Specialist, based in the United Kingdom for providing his Equipment Health Index (HI), which the book's author modified to create the PWI.