CONTRACTOR MANAGEMENT

Developing successful partnerships to boost shutdown efficiency

Shutdowns and Turnarounds 2009 Conference

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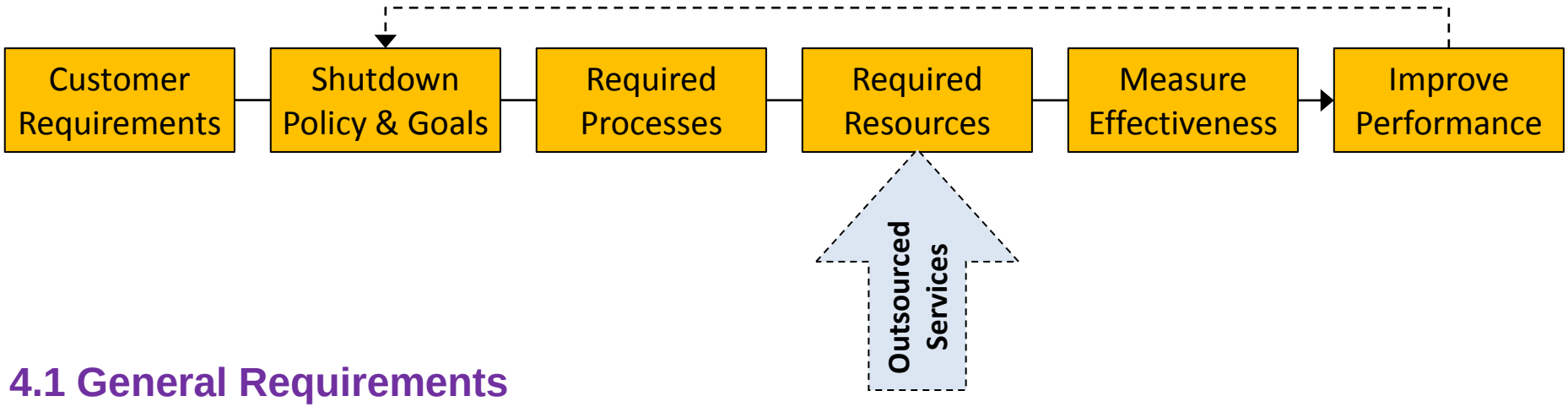
CONTRACTED SERVICES DELIVERY PROCESS MANAGEMENT

Developing successful partnerships to boost shutdown efficiency

Designing a Process with ISO 9001



4.1 General Requirements

NOTE 1: Processes needed for the quality management system referred to above include processes for management activities, provision of resources, product realization and measurement, analysis and improvement.

NOTE 2: An “outsourced process” is a process that the organization needs for its quality management system and which the organization chooses to have performed by an external party.

NOTE 3: Ensuring control over outsourced processes does not absolve the organization of the responsibility of conformity to all customer, statutory and regulatory requirements. The type and extent of control to be applied to the outsourced process may be influenced by factors such as:
a) the potential impact of the outsourced process on the organization’s capability to provide product that conforms to requirements;
b) the degree to which the control for the process is shared;
c) the capability of achieving the necessary control through the application of clause 7.4 (Purchasing).

Problems with Customer Requirements

- **Operations (Customer)**
  - Safety during shutdown
  - Reliability in operation
  - Maintain budget
  - Maintain schedule
  - Flawless start-up
  - Ramp to full production
  - No rework
  - etc

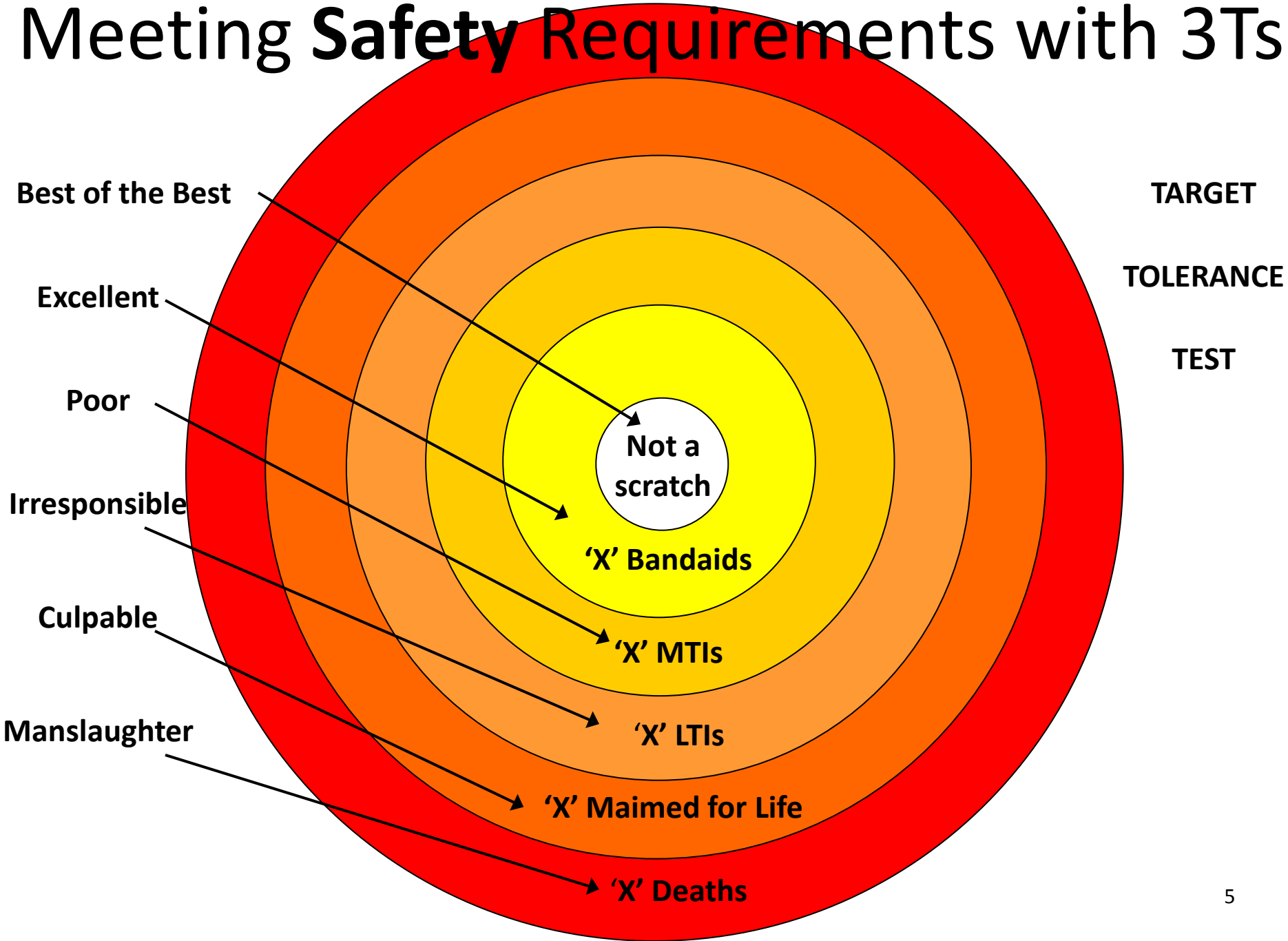
- **Maintenance**
  - Records of all jobs
  - Improve job procedures
  - Improve shut process
  - Improve shut planning
  - Improve materials management
  - Improve purchasing
  - etc

What are the priorities; what is the importance of one over the other ?

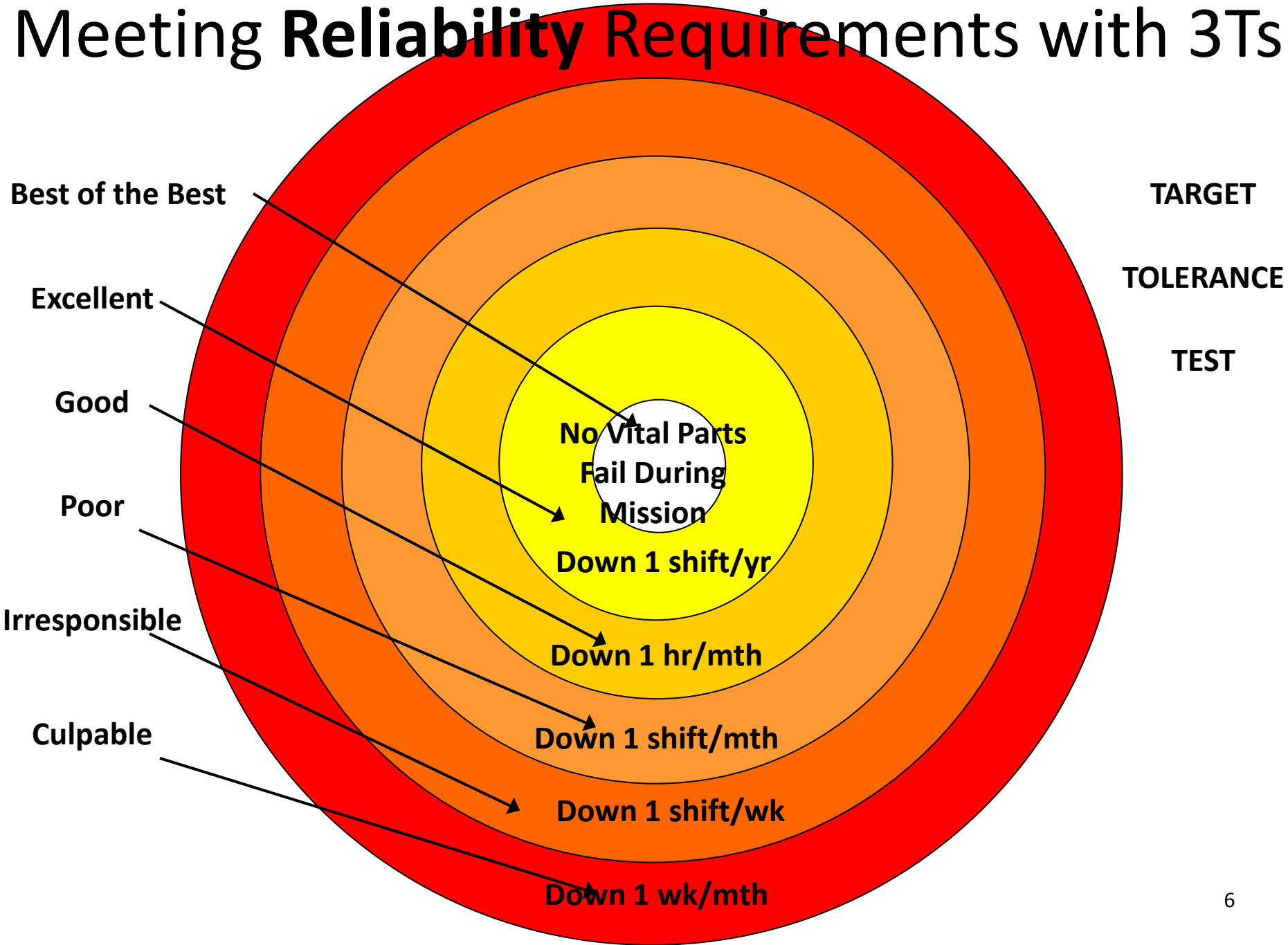
How do you know that you have satisfied the 'customer requirements'?

How good do you need to be?

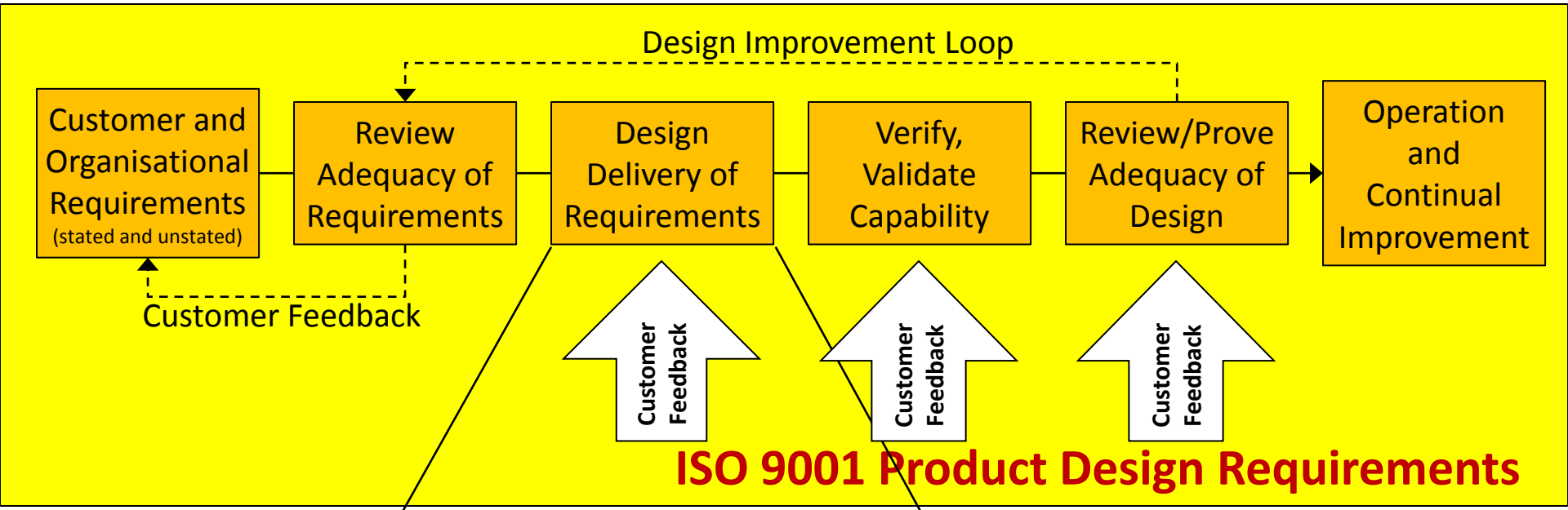
Meeting **Safety** Requirements with 3Ts



Meeting **Reliability** Requirements with 3Ts



Product Realisation Design Process



Your Shutdown System
Processes-Resources-Measures

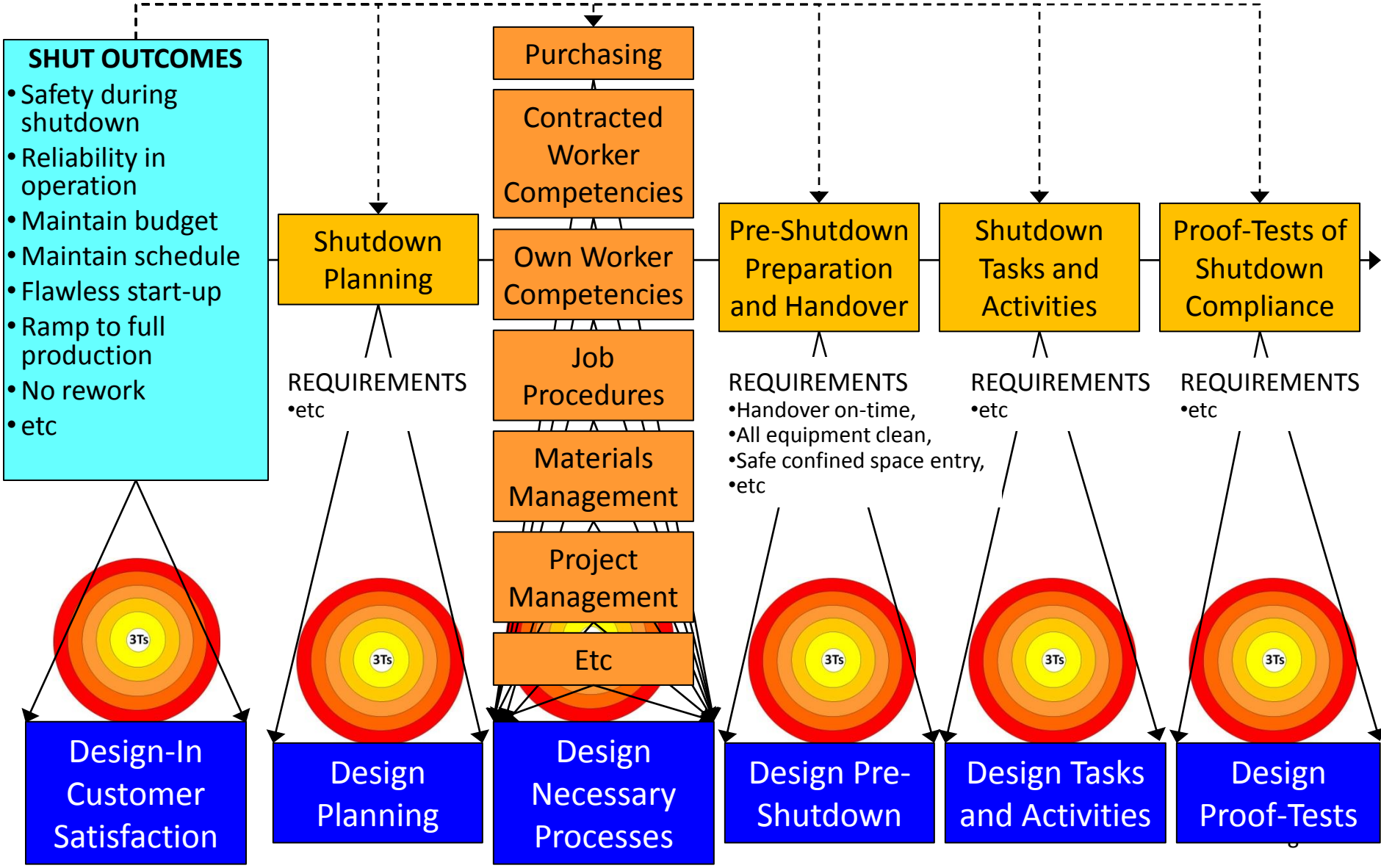
Documentation

Competencies

Responsibilities

ISO9001 Section 7 – Product Realisation explains the design process requirements

Creating the Shutdown 'System'



Cascading Objectives that Tie Directly Back to the Overall Customer Requirements

EXAMPLE

Customer Requirements

Safety = Zero LTIs
Operational Reliability = 24mth zero breakdown
Flawless Start-up = Ramp to 100% capacity

Shutdown Targets

Safety = ?? Equipment Reliability = ?? Financial = ?? Commissioning =??

Shutdown Targets for Contractor A

Safety = ?? Equipment Reliability = ??
Financial = ?? Commissioning =??

Shutdown Targets for Contractor B

Safety = ?? Equipment Reliability = ??
Financial = ?? Commissioning =??

Shutdown Targets for Contractor C

Safety = ?? Equipment Reliability = ??
Financial = ?? Commissioning =??

Shutdown Safety Plans

- Daily pre-start toolbox talks
- Risk analysis of each equipment performed
- Buddy-up for Take-5 pre-job hazard analysis on all work orders

Equipment Reliability Plans

- Off-site competency tests or vital skills retaining
- Pumps 3 yrs MTBF
  - *New pumps purchased comply with API 682 seal for 3 yrs uninterrupted run*
- Compressors 4 yrs MTBF
  - *Detailed and reviewed procedures for vital parts*
- Control valves 8 yrs
  - *Detailed and reviewed procedures for vital parts*

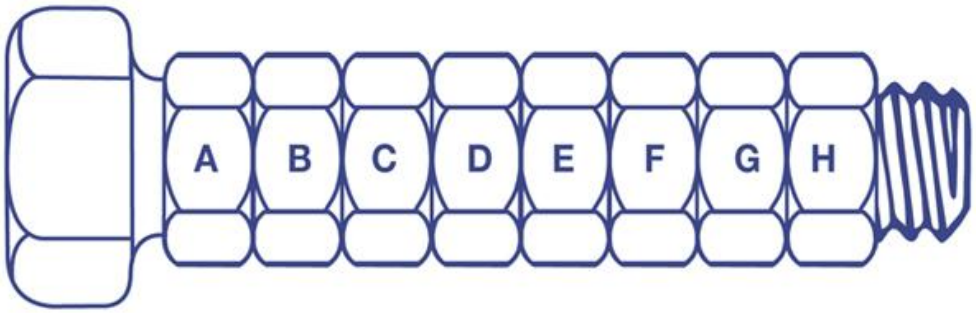
Project Financial Control Plans

- Fully estimated schedule
- Contractors on fixed price with incentive reward

Plant Commissioning Plans

- Do what commissioning can be done as part of job
- Pre-commissioning test plans developed
- Operations write & review Commissioning Plan
- Operators start-up equip
  - *Operators zero check instruments*

The Odds are Against Doing it Right!

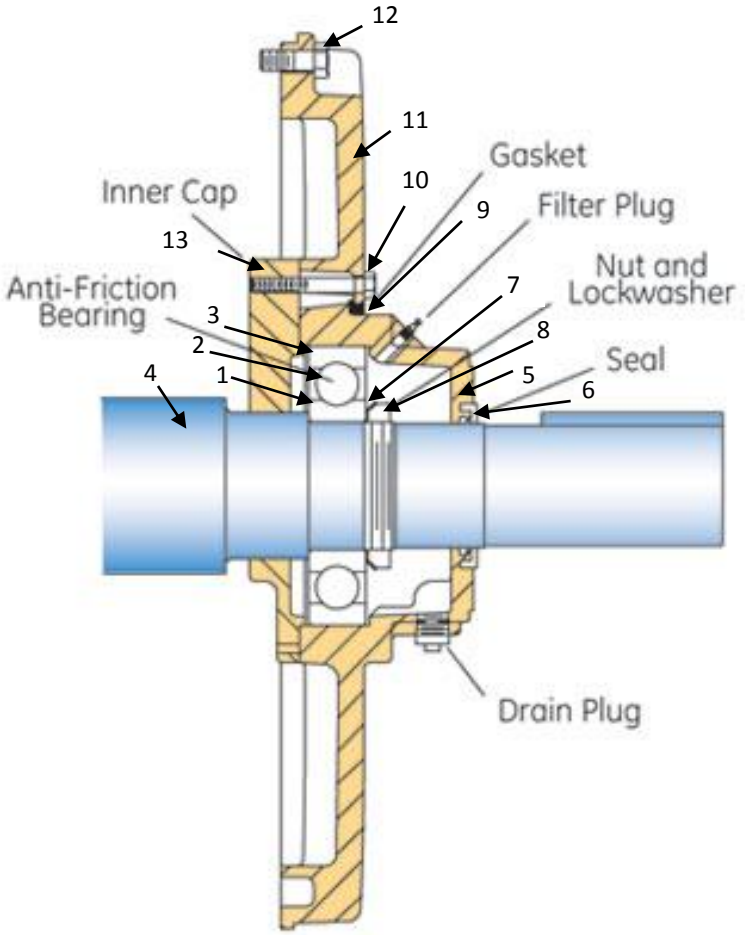


Only one way to disassemble

40,000+ ways to incorrectly reassemble!

Source: US Federal Aviation Authority, 'Maintenance Human Factors Presentation' CD

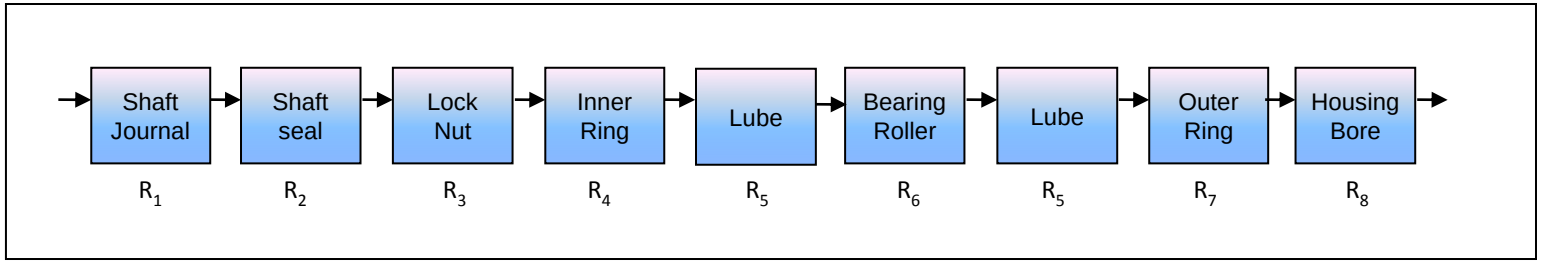
Machines are Components in Series



Electric motor drive end bearing

Calculating Equipment Reliability

Reliability is the **chance** that an item will last long enough to do its duty



$$R_{series} = R_1 \times R_2 \times R_3 \times \ldots R_n$$

R_{series} = 0.999 x 0.999 x 0.999 x 0.999 x 0.999 x 0.999 x 0.999 x 0.999 x 0.999 = $(0.999)^9$ = 0.993

R_{series} = 0.999 x 0.999 x 0.999 x 0.999 x 0.5 x 0.999 x 0.5 x 0.999 x 0.999 = 0.25

"Any poor, all poor"

R_{series} = 0.99 x 0.99 x 0.99 x 0.99 x 0 x 0.99 x 0 x 0.99 x 0.99 = 0

"Any fails, all fails"

The Story in Human Error Rate Tables

	Error rate (per task)		
	Read/ reason	*Physical operation*	*Everyday yardstick*
Simplest possible task			
Fail to respond to annunciator	0.0001		
Overfill bath			0.00001
Fail to isolate supply (electrical work)		0.0001	
Read single alphanumeric wrongly	0.0002		
Read 5-letter word with good resolution wrongly	0.0003		
Select wrong switch (with mimic diagram)		0.0005	
Fail to notice major cross-roads			0.0005
Routine simple task			
Read a checklist or digital display wrongly	0.001		
Set switch (multiposition) wrongly		0.001	
Calibrate dial by potentiometer wrongly		0.002	
Check for wrong indicator in an array	0.003		
Wrongly carry out visual inspection for a defined criterion (e.g. leak)	0.003		
Fail to correctly replace PCB		0.004	
Select wrong switch among similar		0.005	

~5 sigma

~4.5 sigma

	Error rate (per task)		
	Read/ reason	*Physical operation*	*Everyday yardstick*
Read analogue indicator wrongly	0.005		
Read 10-digit number wrongly	0.006		
Leave light on			0.003
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	
Do simple arithmetic wrongly	0.01–0.03		
Wrong selection – vending machine			0.02
Wrongly replace a detailed part		0.02	
Do simple algebra wrongly	0.02		
Read 5-letter word with poor resolution wrongly	0.03		
Put 10 digits into calculator wrongly	0.05		
Dial 10 digits wrongly	0.06		
Complicated non-routine task			
Fail to notice adverse indicator when reaching for wrong switch or item	0.1		
Fail to recognize incorrect status in roving inspection	0.1		
New workshift – fail to check hardware, unless specified	0.1		
General (high stress)	0.25		
Fail to notice wrong position of valves	0.5		
Fail to act correctly after 1 min in emergency situation	0.9		

~4 sigma

~2 - 3 sigma

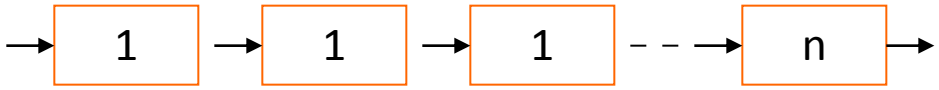
In failure rate terms the incident rate in a plant is likely to be in the range of 20×10^{-6} per h (general human error) to 1×10^{-6} per h (safety-related incident).

Source: Smith, David J., 'Reliability, Maintainability and Risk', Appendix 6, Seventh Edition, Elsevier – Butterworth Heinemann

The Table confirms that 'human element' error is real and <u>unavoidable</u>. We do not perform well when tasks are structured in ways that require care and we perform especially badly under complicated non-routine conditions. Add stress into that that mix and you get disaster.

Reliability Properties for Arrangements

- **Series**

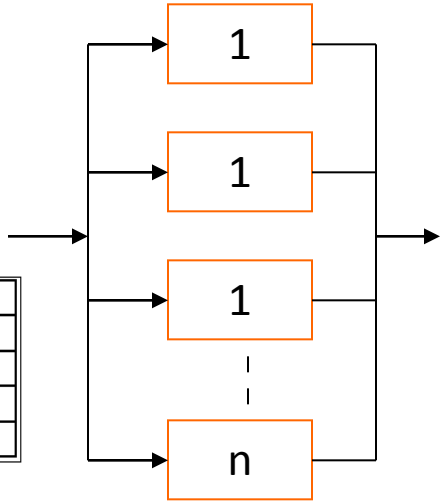


$R_{system} = R_1 \times R_2 \times R_3$

R = 0.95 x 0.95 = **0.9025**

Number of Components	System Reliability
1	0.95
2	0.9025
4	0.8145
6	0.7351
8	0.6634
10	0.5987

- **Parallel**



$R_{system} = 1-[(1- R_1)x(1- R_2)x(1-R_3)]$

R = 1 – [(1 - 0.6) x (1 - 0.6)] = **0.84**

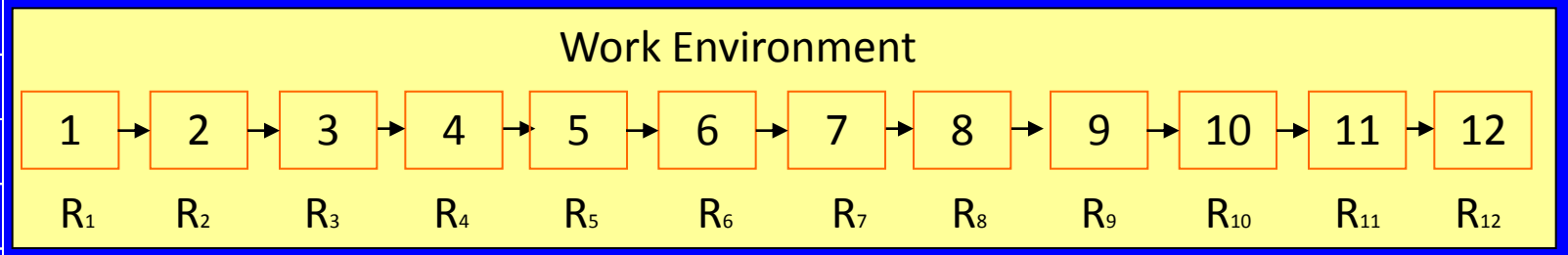
Number of Components	System Reliability
1	0.6
2	0.84
4	0.9744
6	0.9959

Work is a Series Arrangement of Tasks

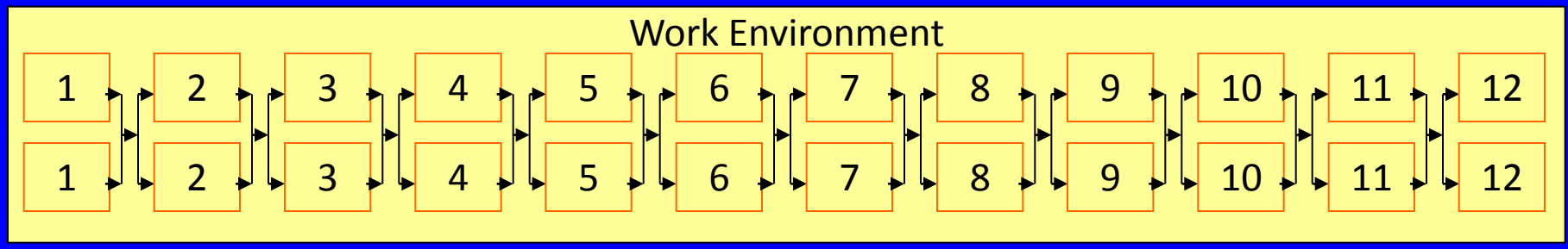
A Maintenance Job …

- Task 1
- Task 2
- Task 3
- Task 4
- Task 5
- Task 6
- Task 7
- Task 8
- Task 9
- Task 10
- Task 11
- Task 12

…is a Series Work Process

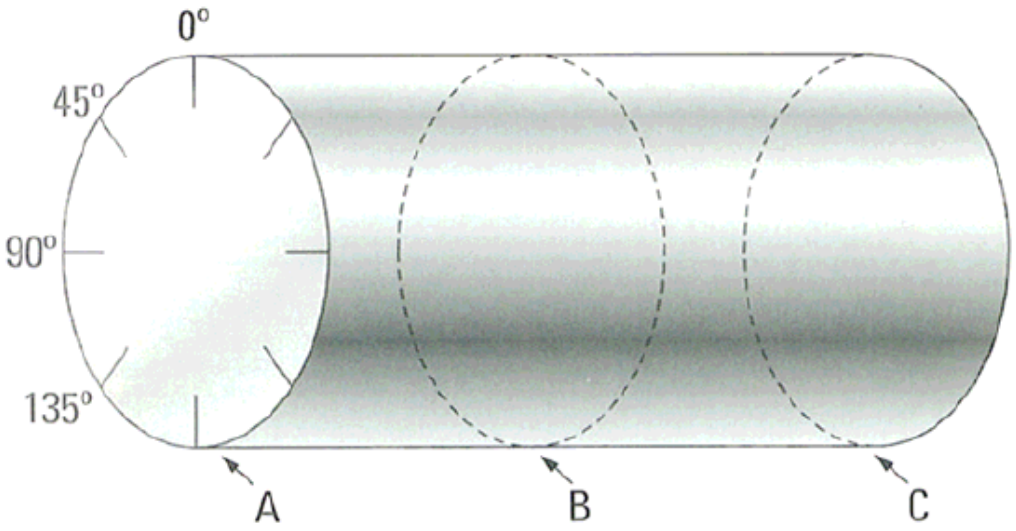


Each task can be made more certain if we can include redundancy and turn it into a parallel arrangement?



A Vital Reliability Requirement

Shaft Tolerances for Bearing Adapter Sleeves



Shaft Diameter		Tolerance h9 µ		Form IT5 µ
over	incl	high	Low	max
10	18	0	-43	8
18	30	0	-52	9
30	50	0	-62	11
50	80	0	-74	13
80	120	0	-87	15
120	180	0	-100	18
180	250	0	-115	20
250	315	0	-130	23
315	400	0	-140	25
400	500	0	-155	27
500	630	0	-175	32
630	800	0	-200	36
800	1 000	0	-230	40
1 000	1 250	0	-260	47

As an example, the measurements for a 150 mm shaft might look like this:

	0°	45°	90°	135°	Plane Average
Plane A	149.98	149.99	149.98	149.99	149.99
Plane B	149.97	149.94	149.98	149.95	149.96
Plane C	149.98	149.98	149.95	149.99	149.98

1) This shaft is not to be used…
but what if you didn't know that until the machine was stripped during a shutdown?

Would your shutdown management process handle the 'discovery' and still deliver the customer requirements of 'Reliability in Operation' with the machine back in service within the shutdown schedule?

2) This shaft will be used…
unless you ensure the problems with the shaft are surely identified so corrective actions can be taken.

How does you shutdwon management process guarantee that will always happen?

a. Taper Evaluation

Compare the maximum and minimum average diameters for the three planes.
If the Max-Min is less than the IT5 tolerance, then the shaft is okay for taper.

	0°	45°	90°	135°	Plane Average
Plane A	149.98	149.99	149.98	149.99	149.99
Plane B	149.97	149.94	149.98	149.95	149.96
Plane C	149.98	149.98	149.95	149.99	149.98
Max-Min					0.03

In this example the "Max-Min" value is 0.03.
The IT5 tolerance is 0.02, so the shaft has excessive taper.

b. Roundness Evaluation

Compare the maximum and minimum values for Plane A.
If the difference is less than the IT5 tolerance, then this plane is okay for roundness.
Repeat for Planes B and C.

	0°	45°	90°	135°	Plane Average	Max-Min
Plane A	149.98	149.99	149.98	149.99	149.99	0.01
Plane B	149.97	149.94	149.98	149.95	149.96	0.04
Plane C	149.98	149.98	149.95	149.99	149.98	0.04

In this example the "Max-Min" values are 0.01, 0.04, and 0.04.
The tolerance is 0.02, so Planes B and C are out of round.

c. Cylindricity Evaluation

Compare the maximum and minimum values for each angle of measurement.
If the difference is less than the IT5 tolerance for all angles, then the shaft is okay for cylindricity.

	0°	45°	90°	135°	Plane Average
Plane A	149.98	149.99	149.98	149.99	149.99
Plane B	149.97	149.94	149.98	149.95	149.96
Plane C	149.98	149.98	149.95	149.99	149.98
Max-Min	0.01	0.05	0.03	0.04	

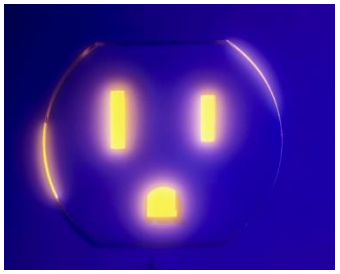
In this example the "Max-Min" values are 0.01, 0.05, 0.03 and 0.04.
The tolerance is 0.02, so the shaft is not cylindrical.

Is This Okay for Your Machines?

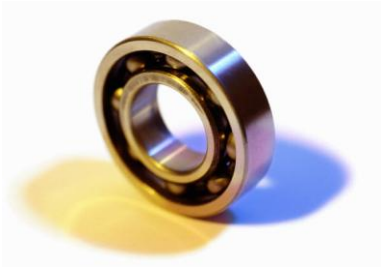
What Risks will You Accept










ISO 9001:2008 on Competency

<u>Competency:</u> The ability to achieve the desired results.

<u>Qualified:</u> The appropriate education, training and skills to perform a job.

They are not the same!

Competence is about what people can deliver … the demonstrated ability to use knowledge, skills and behaviours to achieve the results required of the role.

#1: It means delivering the required outcomes

#2: It requires meeting set performance standards

#3: It is shown by the ability to perform the whole role in the work environment – a real and demonstrated capability

ISO 9001:2008 on Competency

Clause 6.2.1 *"Personnel performing work affecting conformity of product requirements SHALL be competent on the basis of appropriate education, training, skills and experience."*

Clause 6.2.2a *"The organisation SHALL determine the necessary competence for personnel performing work affecting conformity to product requirements."*

Clause 6.2.2b *"The organisation SHALL where applicable provide training or take other actions to satisfy these needs."*

Clause 6.2.2c *"The organisation SHALL ensure that the necessary competence has been achieved."*

Clause 6.2.2d *"The organisation SHALL ensure that its personnel are aware of the relevance and importance of their activities and how they contribute to the achievement of the quality objectives, and."*

Clause 6.2.2e *"The organisation SHALL maintain appropriate records of education, training, skills and experience."*

Helping People to Get it Right

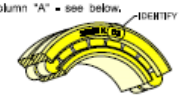
Consolidated Bearing Company — **FITTING OF TAPERED BORE SPHERICAL ROLLER BEARINGS** — NTN

1.

Unwrap bearing and inspect for internal clearance group.

When supplied with housings they will usually be :-
"Normal clearance" – no suffix after number,
-or-
"C3 clearance" – one group greater than normal.

Multiply last two numerals of bearing number by 5 to determine nominal bore size in millimetres for reference to table column "A" - see below.

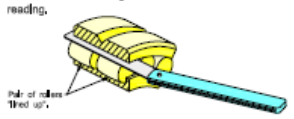


Example 1 :- 22232 32 x 5 = 160mm nominal bore.

Note • Bearing bore diameter, not adapter bore diameter.
• Suffix 'K' denotes 1 : 12 tapered bore.
• Suffix 'K30' denotes 1 : 30 tapered bore.

2.

Measure bearing radial clearance with feeler gauges, as shown, and record measured internal clearance. Two rollers should be lined up side by side at the top of the bearing and progressively larger feelers slid between rollers and outer race until beginning of interference is felt. Under no circumstances should bearing be rotated to "roll" feelers through - this will result in an erroneous reading.



Example 1 (cont.) :- Assume this bearing measured 0,210mm internal clearance.

Note Use "long series" feeler gauges so that blades pass simultaneously across both rollers.

3.

When actual internal clearance is determined it can be checked with ISO standard range for that bearing, (See table column "B"). From actual clearance measured, subtract "required reduction in radial clearance" from column "C"; this will determine the required "residual clearance" for that bearing.

Example 1 (cont.) :-

I 22232 K C3 measured 0.210mm, actual ISO standard "B". 0.180 to 0.230mm, therefore bearing falls in the correct group - C3.

II Read "Required reduction in radial clearance" from column "C", 22232 K C3 ; 0,075 to 0,100mm

III Residual clearance ;
Max = 0,210 minus 0,075 = 0,135mm
Min = 0,210 minus 0,100 = 0,110mm

This residual clearance range is what the bearing clearance should be within, after tightening adapter, (Step 7).

4.

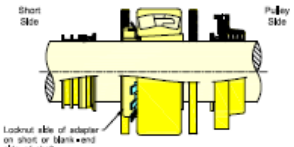
Bearing should be "located" or "fixed" in one housing and allowed to "float" in the other. Therefore spacer rings need to be used in one housing only. One or two spacer rings are used according to bearing size (see C B C housing catalogue). If one is used it should be located on locknut side of sleeve, if two are used they should be positioned each side of bearing.

Two types of spacer rings are commonly used :-
a) Solid type (fully circular) b) Gap type

Gap types can be fitted over shaft after bearing and seals have been fitted. Solid types must be included in progressive assembly, so check type of spacer prior to Step 5. Gap can also be cut from solid type supplied.

5.

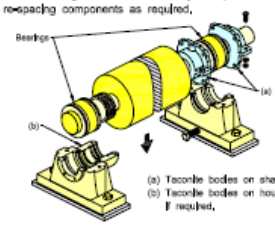
Bearings, adapter sleeves, rotating seal components (and spacer rings if sold), should be fitted loosely to shaft in approximately required positions. In many cases the taconite seals (with outer cover) can be positioned already assembled - otherwise rotating labyrinth and lip seal can be positioned loosely.



6.

After clearing, set up bases in position, fit base bolts (if on base frame) but leave loose so that bases can be moved later to provide correct shaft alignment.

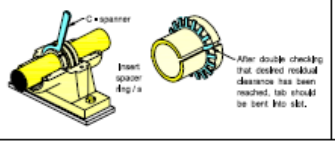
Lower bearings and shaft assembly into position carefully, re-spacing components as required.



(a) Taconite bodies on shaft.
(b) Taconite bodies on housing if required.

7.

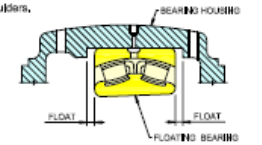
When bearings are in position the adapter sleeves can be tightened. Fixed bearing should be tightened first, C - spanners should be used where possible. Progressively tighten locknut whilst feeler gauge readings are taken (similar to Step 2) to achieve desired "residual clearance" (Step 3). Suggested method is to select mid-range feeler; in case of example, use 0,140mm blade and tighten until slight interference is felt. When approaching this condition watch for locknut slot nearing alignment with a lockwasher tab.



8.

The floating bearing should now be positioned slightly off housing centre toward locknut side of sleeve so that as nut is tightened, bearing will be displaced, as per column "D" below, approximately back to centre line. Tighten as per Step 7.

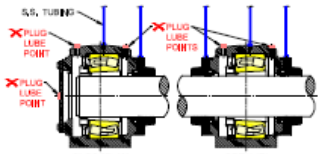
No spacer rings are used of course, and bearing does not have to be on centre as long as adequate float is available each side of bearing between housing seat shoulders.



Rotate assembly by hand and ensure that there is no resistance.

9.

Lithium based greases with medium base oil viscosities are normally used to lubricate bearings in plummer block housings. All the free space within the bearing should be packed full of grease by hand, 1/3 of the remaining volume in the housing cavity should then be filled. For feed rates, high temperatures, high speeds, or other unusual application requirements, please contact C B C.



PREFERRED NIPPLE CONNECTIONS

10.

Housing caps, after clearing, can be assembled to bodies (they are not generally interchangeable).

Taconite seals should be fitted and it may be necessary to adjust housing base alignment to allow constant clearance around circumference of rotating labyrinth and taconite cover body.

Feeler gauge (say 0,12mm) should be "tried" between housing base and frame pad to ensure flatness and that shims are not required. Base bolts can then be tightened. Check continually during these procedures that rotation is free and not impaired.

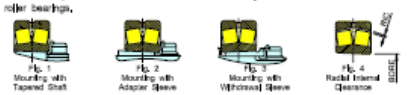
Taconite seals should be lubricated until grease extrudes fully around labyrinth circumference. Do not overgrease the bearing itself as damage from over - heating can occur during initial running period. It should be lubricated and plugged as per Step 9.

General Notes:

a Table values are for normal loads, solid shafts and bearing internal clearance groups of 'Normal', C3 and C4. For heavy loads (Pr > 0,12 Cr) please consult C B C.
b After determining residual clearance in Step 3, consult column "E" in table as a double check that the final figure achieved does not fall below the minimum permissible residual clearance.
c In some applications it may not be possible to use feeler gauges to serve as a tightening guide. In these cases it is often possible to measure "axial displacement" between adapter sleeve and inner face of bearing during tightening (see chart column "D"). These values are for relative movement between sleeve and bearing faces and can be measured with the depth gauge of a standard vernier gauge, or other methods.
d All joint faces are machined. Grease applied between faces should be sufficient to act as a sealant. However, in exposed locations we recommend joining compound be used, especially with type 'A' (closed) covers - see Step 9.
e As with all bearing assemblies, tools and work area should be kept as clean as practicable.
f Check that the shaft diameter conforms to ISO tolerance h9, and IT5 for ovality - see Sheet 3 / 4.
2

This section presented on separate plastic C B C fitting card - MOUNTING NTN TAPERED BORE SPHERICAL ROLLER BEARINGS

Tapered bore spherical bearings are mounted on tapered shafts (Fig. 1) or on tapered shaft sleeves. The sleeves can be either adapter or withdrawal configurations (Fig. 2 and 3). Correct shaft mounting is dependent on the axial displacement of the bearing along the tapered seat. This axial displacement produces an interference fit which decreases the bearing radial internal clearance (RIC). RIC measurement before and during mounting is the preferred method to check adequacy of shaft fit (Fig. 4). Recommended RIC reductions are listed in the table opposite. To measure the unmounted RIC, place the bearing in an upright position and centre the inner and outer rings. Rotate the inner ring several times to properly seat the rollers. Restrain the roller at the top of the bearing and insert feeler gauge blades between the outer ring and the rollers. See (2,) above. Be sure to cover the full roller length. The RIC is the thickest blade that will slide through. Both bearing rows should be checked in this manner simultaneously. During mounting, the RIC should be measured at the unloaded rollers. This may be at the top or bottom of the bearing depending on the application. The rollers must be seated during the process. Axial displacement should continue until the recommended RIC reduction has been achieved. The mounted RIC should not be less than the minimum permissible value quoted in the column "E" of the table. Hydraulic nuts are recommended for mounting larger spherical roller bearings.



Example 2 :-
Bearing 22328 K C3 (140mm bore, taper 1:12) is being mounted on an adapter sleeve.
I Using feeler gauge, measure unmounted RIC. From the table, it should measure between 0.160mm and 0.200mm.
II Move bearing on sleeve until bearing bore is properly seated on the tapered sleeve, to start with.
III Using a locknut or hydraulic nut, drive bearing up tapered seat until RIC is reduced by 0.065mm to 0.095mm.
IV If(a) measured RIC should not be less than 0,06mm as per column "E".

Nominal bearing bore diameter (d)		Initial Clearance B						Required reduction in radial clearance C		Axial Displacement Taper 1/12 D				Axial Displacement Taper 1/30 D				Minimum permissible residual clearance E		
		Normal		C3		C4				Shaft		Sleeve		Shaft		Sleeve				
over	incl.	min	max	min	max	min	max	min	max	min	max	min	max	min	max	min	max	Normal	C3	C4
30	40	0.035	0.050	0.050	0.065	0.065	0.080	0.020	0.025	0.350	0.400	0.350	0.400	–	–	–	–	0.025	0.025	0.040
40	50	0.045	0.060	0.060	0.080	0.080	0.100	0.025	0.030	0.400	0.450	0.450	0.500	–	–	–	–	0.030	0.030	0.050
50	65	0.055	0.075	0.075	0.095	0.095	0.120	0.030	0.040	0.450	0.500	0.500	0.550	–	–	–	–	0.035	0.035	0.060
65	80	0.070	0.095	0.095	0.120	0.120	0.150	0.040	0.050	0.500	0.750	0.700	0.850	–	–	–	–	0.045	0.045	0.070
80	100	0.080	0.110	0.110	0.140	0.140	0.180	0.045	0.060	0.700	0.900	0.750	1.000	1.700	2.200	1.800	2.400	0.055	0.055	0.080
100	120	0.100	0.135	0.135	0.170	0.170	0.220	0.050	0.070	0.700	1.000	0.900	1.200	1.700	2.200	2.000	2.600	0.065	0.065	0.100
120	140	0.120	0.160	0.160	0.200	0.200	0.260	0.065	0.090	1.000	1.400	1.200	1.500	2.100	3.500	2.800	3.600	0.085	0.085	0.130
140	160	0.130	0.180	0.180	0.230	0.230	0.300	0.075	0.100	1.200	1.600	1.500	1.700	3.600	4.000	3.200	4.200	0.095	0.095	0.150
160	180	0.140	0.200	0.200	0.250	0.250	0.340	0.090	0.120	1.500	1.700	1.600	1.900	3.700	4.200	3.300	4.300	0.095	0.095	0.150
180	200	0.150	0.220	0.220	0.280	0.280	0.380	0.090	0.120	1.600	2.000	1.700	2.200	3.700	4.200	3.300	4.300	0.095	0.095	0.150
200	225	0.180	0.250	0.250	0.320	0.320	0.430	0.100	0.140	1.800	2.200	1.900	2.400	4.000	5.500	4.200	5.700	0.100	0.100	0.160
225	250	0.200	0.270	0.270	0.350	0.350	0.470	0.110	0.150	1.900	2.400	2.000	2.600	4.200	6.000	4.600	6.200	0.090	0.090	0.200
250	280	0.220	0.300	0.300	0.390	0.390	0.520	0.120	0.170	1.900	2.600	2.000	2.800	4.200	6.000	4.600	6.200	0.100	0.100	0.220
280	315	0.240	0.330	0.330	0.430	0.430	0.560	0.130	0.190	2.000	2.800	2.200	3.000	4.500	7.500	5.200	7.700	0.110	0.110	0.240
315	355	0.270	0.360	0.360	0.470	0.470	0.610	0.150	0.210	2.400	3.400	2.600	3.600	6.000	8.200	6.200	8.600	0.120	0.120	0.260
355	400	0.300	0.400	0.400	0.520	0.520	0.680	0.170	0.230	2.600	3.600	2.900	3.900	6.500	9.000	6.800	9.200	0.120	0.120	0.290
400	450	0.330	0.440	0.440	0.570	0.570	0.750	0.200	0.260	2.900	4.000	3.200	4.400	7.700	10.600	8.000	10.600	0.130	0.130	0.310
450	500	0.370	0.490	0.490	0.630	0.630	0.790	0.220	0.280	3.300	4.400	3.600	4.800	8.200	11.000	8.400	11.200	0.160	0.230	0.350
500	560	0.410	0.540	0.540	0.680	0.680	0.870	0.240	0.320	3.700	5.000	4.100	5.400	9.200	12.500	9.000	12.000	0.170	0.250	0.360
560	630	0.460	0.600	0.600	0.760	0.760	0.980	0.260	0.350	4.000	5.400	4.400	5.900	10.000	13.500	10.400	14.000	0.200	0.290	0.410
630	710	0.520	0.670	0.670	0.850	0.850	1.090	0.300	0.400	4.600	6.200	5.100	6.800	11.500	15.500	12.000	16.000	0.210	0.310	0.450
710	800	0.570	0.750	0.750	0.960	0.960	1.220	0.340	0.450	5.300	7.100	5.800	7.600	13.200	17.500	13.600	18.000	0.230	0.350	0.510
800	900	0.640	0.840	0.840	1.070	1.070	1.370	0.380	0.500	5.700	7.800	6.300	8.500	14.300	19.500	15.000	20.000	0.270	0.390	0.570
900	1000	0.710	0.930	0.930	1.190	1.190	1.520	0.410	0.550	6.300	8.500	7.000	9.400	15.800	21.000	16.600	22.000	0.300	0.430	0.640
1000	1120	0.770	1.010	1.010	1.300	1.300	1.670	0.450	0.600	6.800	9.000	7.600	10.200	17.000	23.000	18.000	24.000	0.320	0.480	0.700
1120	1250	0.830	1.120	1.120	1.420	1.420	1.810	0.490	0.650	7.400	9.800	8.300	11.000	18.500	25.000	19.600	26.000	0.340	0.540	0.770
1250	1400	0.910	1.220	1.220	1.560	1.560	2.000	0.550	0.720	8.200	10.800	9.200	12.100	20.600	27.000	22.200	28.200	0.360	0.590	0.840
1400	1600	1.000	1.350	1.350	1.720	1.720	2.200	0.600	0.810	9.200	12.200	10.600	13.800	23.000	30.000	24.200	31.400	0.440	0.660	0.940
1600	1800	1.110	1.500	1.500	1.910	1.910	2.460	0.690	0.930	10.400	14.200	11.700	15.800	26.200	35.200	27.600	37.200	0.480	0.730	1.020

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CBC BEARINGS POWER TRANSMISSION

FITTING OF TAPERED BORE SPHERICAL ROLLER BEARINGS AND "P" STANDARD HOUSINGS

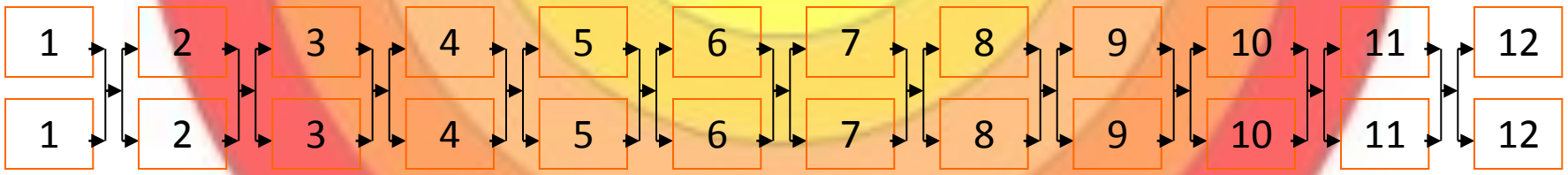
A1 Sheet — CBC - DC - 11 — A Issue

Addressing Skills Requirements

…so you can meeting reliability, safety, flawless start-up, and all the other requirements

Customer Requirements
Safety = Zero LTIs Operational Reliability = 24mth zero breakdown Flawless Start-up = Ramp to 100% capacity

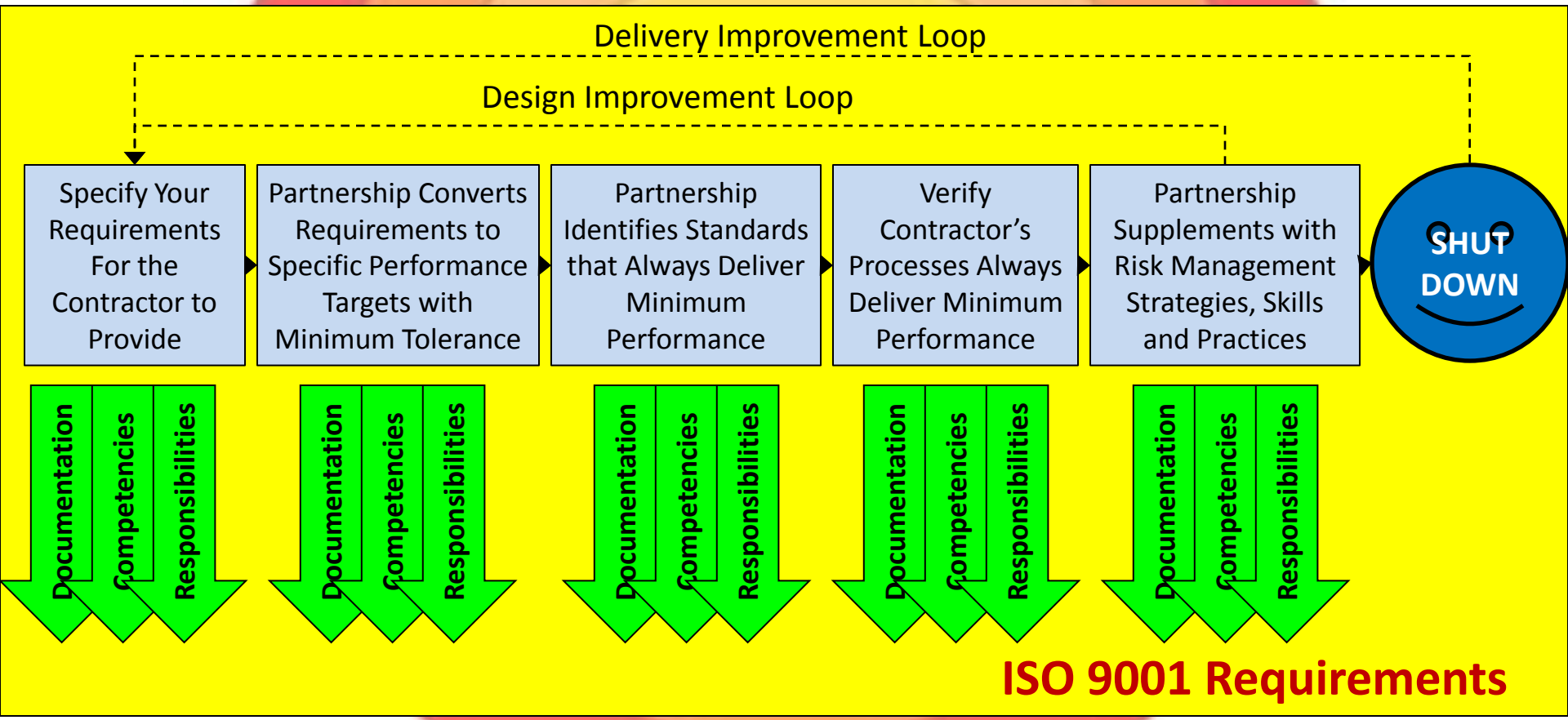
- Specify **necessary skills to do a task to the minimum standard needed to meet Requirements**
- For a **vital skill** to successfully meeting Requirements have **evidence of 'skill competence'**
- If necessary **parallel those who have adequate skills with 'equipment competent' people**



- **Don't use those who haven't the necessary skills** e.g. structural steel installers fitting bearings

CONTRACTED SERVICES DELIVERY PROCESS MANAGEMENT

Developing successful partnerships to boost shutdown efficiency



The Power of a Shared Vision