Coal Handling Plant Alignment Standards For Shaft To Shaft Alignment

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1.0 Abstract: -

Shaft alignment is a technical skill that is not common in the construction and maintenance professions, but categorized more like a specialty. It requires unique and expensive measurement instruments, some calculation capability, and relies heavily on experience for successful results on heavy, high-speed, or high-temperature machines. At present there are no universally accepted standards that define good results. This paper covers alignment standard for Four-dial indicator method. All these standards are developed only on experience basic which are useful for alignments in Thermal Power Station’s Coal Handling Plants. The goal of these standards is to provide the technician with the recommended approach for the quality alignment.

2.0 Introduction: -

Over the past twenty years, the level of awareness concerning the importance of accurate and precise shaft alignment has increased dramatically. In would therefore appear that shaft alignment seems to have taken a more important role when installing and maintaining machinery

Effects of shaft misalignment is reduction in operating life span of rotating machinery Since the components that are most likely to fail are the bearings, seals, coupling, and shafts due to inaccurately aligned machinery. In fact, quality alignment is not dependent on the type of measurement system used. Any good dial indicator set is sufficient to perform quality alignments. In contrast, the goal of alignment technique is meet the standards. Standards are a means of scooping the work expected of technician. By precisely defining the results, standards are a means of controlling the cost to the level where the results are achieved and no more. Whether alignment is done in-house, or as a contracted service, the results should be consistently the same when the same standards are enforced.

3.0 Effects of Misalignments: -

- Excessive axial and radial forces on the bearings, which reduce longer bearing life and rotor stability under dynamic operating conditions.
- Increase shaft bending from the point of power transmission in the coupling to the coupling end bearing.
- Increases wear in the coupling components.
- Possibility of shaft failure from cyclic fatigue.
- Possibility of increase vibration levels in machine casings, bearing housings, and rotors
- Premature bearing, seal, shaft, or coupling failures.

4.0 Symptoms of misalignment: -

High casing temperatures at or near the bearings or high discharge oil temperatures.

Excessive amount of oil leakage at the bearing seals.

Loose foundation bolts.

High number of coupling bolts failures, coupling bush failures, gear teeth of coupling failures or they wear quickly.

Excessive amounts of grease (or oil) on the inside of the coupling guard

5.0 Classification of Misalignment: -

For a flexible coupling to accept both parallel and angular misalignment there must be at least two points where the coupling can 'flex' or give to accommodate the misalignment condition. The goal of the person doing the alignment is to position the machinery casings such that all of these deviations are below certain tolerance values. Therefore misalignment can be classify [1] into four grades depend on the details from different manufacture including bearing manufacturers, coupling manufacturers, alignment system consultants and so on.

1. Unsafe: the degree of misalignment is outside the tolerance limit.
2. Poor: the degree of misalignment is inside the tolerance limit but outside the recommended limit.
3. Acceptable: the degree of misalignment is in the recommended range for operating.
4. Excellent: the degree of misalignment is close to perfect alignment.

A tolerance chart is shown in figure 1 that will help in establishing a goal for the people who are doing the alignment. The data in this graph was compiled from a large number of case histories while carrying the alignment work in coal handling plant.

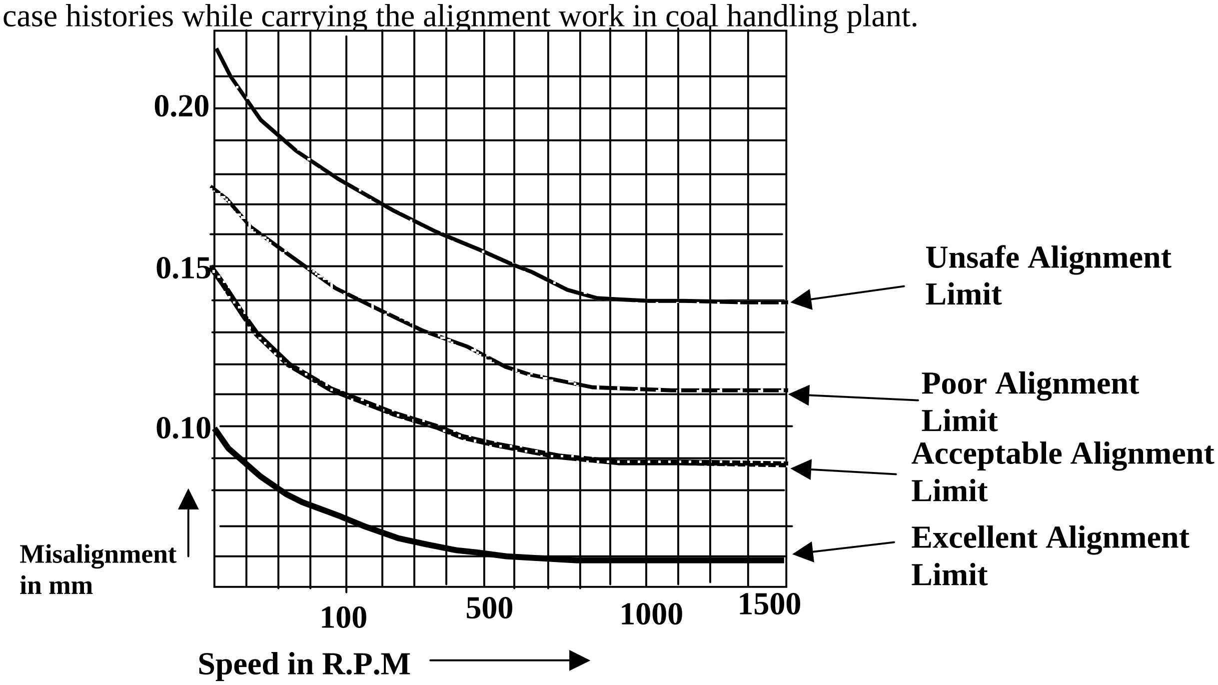

Figure No 1

6.0<u>Alignment standards</u>: -

The purpose of this standard is to guarantee reliability of mechanical equipment when first placed into service and after major repair. It specifies the alignment condition of components to reduce vibration and minimize wear.

The purposes of this standard are given below.

- The equipment is guaranteed for minimum dynamic forces and wear.
- To detect grossly defective components, like bent shafts

This standard defines acceptable limits for shaft-to-shaft alignment of coupled machines. The limits are defined in terms of axial offset and radial offset. Acceptable shim materials are defined.

6.1<u>Standard of measurement system</u>: -

The measurement system needs to be repeatable to within 0.01 mm when exercised through one complete cycle. Repeatability is the significant characteristic that guarantees adherence to the specifications. The measurement system shall be checked for repeatability at the start of each alignment task after the system is fixture in place on the machine. The machine shafts shall be rotated (a full 360^0 rotation) and the shaft

orientation returned to the starting point. The measuring system shall read to within 0.01 mm of the initial reading. If it does not, then the measurement system is not useable for alignment purposes.
As there may gravity sag to alignment fixture, which creates an error greater than 0.01 mm, then it shall be corrected.
Mechanical dial indicators, properly fixture, are acceptable as measuring devices.

6.2<u>Shims</u>: -

Only stainless-steel pre-stamped shim [2] shall be added. Brass, plastic, aluminum, or unplated low-carbon steel shims are unacceptable in thickness less than 0.5mm. Thick spacer blocks, or risers, of these materials are acceptable when thicker than 0.5mm.

6.3 <u>Alignment limits</u>: -

The shaft-to-shaft residual misalignment is acceptable when the intersection point of the two shafts is within the coupling area and the included angle between the shaft centerlines is small. These two criteria must be applied in two orthogonal directions, typically horizontal and vertical for convenience, and normalized to speed. That is, slow-speed machines are allowed a larger tolerance. High-speed machines are required to be better aligned. The tolerance values from the Tables No 1 suggested standards based on experience basis while carrying the alignment work in coal handling plant. The objective with these standards is to minimize wear and achieve reliable life. The axial tolerance is given per 100mm of distance of dial gauge tip from center of shaft.

	Axial misalignment /100mm		**Radial misalignment**	
	Acceptable limit	**Excellent**	**Acceptable limit**	**Excellent**
Motor and gearbox of conveyors	0.04mm	0.02mm	0.06mm	0.02mm
Gearbox and drive pulley of conveyors	0.08mm	0.02mm	0.1mm	0.04mm
Wagon tippler gearbox and motor	0.06mm	0.02mm	0.08mm	0.03mm
Crusher drive	0.04mm	0.02mm	0.06mm	0.03mm
Crusher gearbox and crusher drive pulley	0.06mm	0.02mm	0.08mm	0.02mm
Crushers gearbox and motor	0.04mm	0.02mm	0.04mm	0.02mm

Table No 1

6.3.1 <u>Alignment Curves</u>: -

The readings are taken from ‘Four Dial Gauge’ method [3]. After receiving the set of readings the curve is plotted. These curves are shown in Figure No 2.
For comparison of values, the values should be assumed non-vector values.
For radial alignment it should satisfy
m = n, q = t and r = s
& In m, n, q, t, r, s, which is the greater, is the radial clearance.

For axial alignment it should satisfy
e = j, k = l and u = v
& In e, j, k, l, u, v, which is the greater, is the axial movement of shaft. This can be combined or indivisusal result of improper bearing loading and relative movement of shaft with respective inner race of bearing. This axial movement can be less than actual axial movement.
Difference between m and n or q and t or r and s, which is greater, is known as radial error. The acceptable radial error is given in column Y. The column Y_1 is the acceptable difference between the radial error and radial clearance. Above this the machine is to check for further defects.
Difference between e and j or k and l or u and v, which is greater, is known as axial error. The acceptable axial error is given in column Z. The column Z_1 is the acceptable difference between the axial error and axial movement. Above this the machine is to check for further defects.

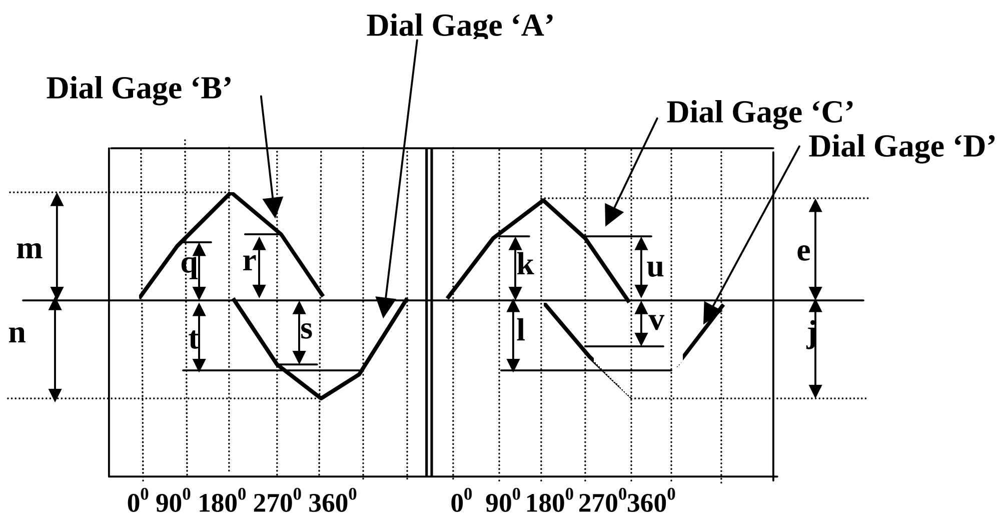

Figure No 2

	Axial		Radial	
	Z_1	Z	Y_1	Y
Motor and gearbox of conveyors	0.04mm	0.04mm	0.04mm	0.06mm
Gearbox and drive pulley of conveyors	0.02mm	0.08mm	0.04mm	0.1mm
Wagon tippler gearbox and motor	0.04mm	0.06mm	0.02mm	0.08mm
Crusher drive	0.02mm	0.04mm	0.02mm	0.06mm
Crusher gearbox and crusher drive pulley	0.04mm	0.06mm	0.04mm	0.08mm
Crusher gearbox and motor	0.04mm	0.04mm	0.04mm	0.04mm

Table no 2

7.0 <u>Estimate Time Failure Due To Shaft Misalignments</u>: -

Flexible couplings accommodate slight misalignment. But the shafts are flexible too, and as the misalignment becomes more severe, the more the shafts begin to flexible also. The shafts are not permanently bent; they are just elastically bending as they undergo rotation. The chart in Figure No 3 illustrates the estimated period to failure of a typical piece of rotating equipment based on varying alignment conditions. The term 'failure' here implies a degradation of any critical component of the machine such as the oil seals, bearings, coupling, or rotors. The data in this graph was compiled from a large number of case histories while carrying the alignment work in coal handling plant.

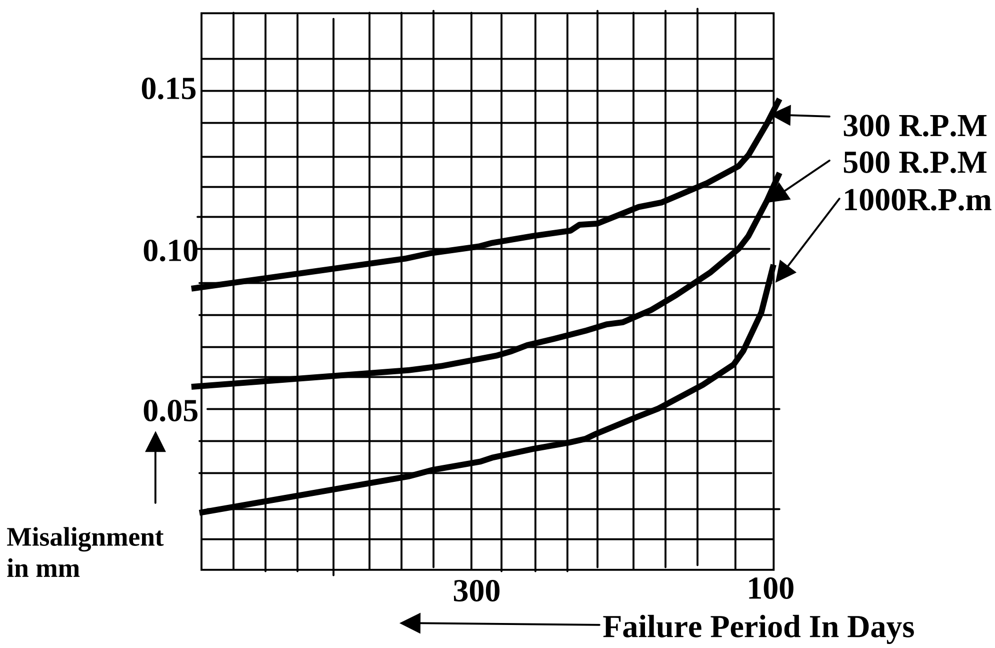

Figure No 3

7.0 <u>Conclusion</u>: -

The alignment standard suggested for Four-dial gage method, which provides the technician the recommended approach for the quickest way with quality alignment.

For this method it is necessary to record all four cardinal readings.

These standards are useful only for shaft-to-shaft alignment of Thermal Power Station's Coal Handling Plants. It can be used up to some extent to other area.

All these values of standards are built in experience basis and further it is required to develop mathematical relations for all these standard value.

<u>References</u>: -

1. Research paper on "Misalignment and vibration detection in Electrical Machine" by M. Pusayatanont, Department of Electrical and Electronics Engineering, Ubonratchatani University.
2. Research paper on "Specifying Shaft Alignment" By Victor Wowk, P.E., published in Applied Technology Publications, Inc.1300 S. Grove Ave., Suite 105, Barrington, IL
3. Article on "Shaft To Shaft Alignment By Four-Dial Gage Method For Coal Handling Plant- New Approach" by Makarand Joshi received from www.plant-maintenance.com/articles/ShaftAlignment.pdf.