1 Scope

1.1 This procedure provides guidelines for inspection of Pump Shafts for combined electrical and mechanical runout (TIR) examination. Acceptance criteria are defined per the engineering drawings referenced on the Production Order or Sulzer Purchase Order. This test procedure only describes the general requirements and should be supplemented by a local work instruction.

Background information regarding design parameters of shaft probe tracks see Appendix 1.

An example of how to determine probe sensitivity values for different materials see Appendix 2.

2 Reference Documents

2.1 All standards used shall be the current revision unless stated otherwise.

2.2 Sulzer TQ documents referenced in this specification can be downloaded from www.sulzer.com/q-documents .

API 610 / ISO 13709	Centrifugal pumps for petroleum, petrochemical and natural gas industries
API 670	Machinery Protection Systems
Sulzer	
DT-0027	Combined Electrical and Mechanical Runout Report

3 Equipment

3.1 Calibrated measuring and test equipment shall be used to collect all the measurements during the inspection.

3.2 The overall inspection set up should be validated to ensure that it produces correct results.

4 Prerequisites

4.1 The Sensitivity factor, which converts the sensor voltage to inches or microns, is dependent on material type and the sensor used. A method to obtain this value is described in Appendix 2.

4.2 Shaft probe tracks need to be clean and free of grease, oil, dust and other foreign material and have the correct surface finish.

5 Test Process

5.1 Combined Electrical and Mechanical runout shall be measured in the shaft probe tracks (burnished areas) or target rings as shown on the shaft drawing.

5.2 Each probe track shall be tested independently. Typically, when vibration sensing with non-contact displacement probes is required, there will be a Drive End probe track and a Non-Drive End probe track.

5.3 The shaft shall be supported in such a way to prevent eccentricity at the probe target diameters that would create false readings.

5.4 Install displacement probes using firm supports to ensure that external vibration does not affect measurement.

5.5 Measurements can be taken in discrete steps not to exceed a 45 degree turn of the shaft or the high (TIR_{max}) and low peaks (TIR_{min}) can be measured while rotating the shaft at a low speed (under 100 rpm). *Caution: electromagnetic interference generated by machine tools can distort sensor readings.*

5.6 If discrete measurements are taken, calculate the runout from R1 and R2 data for each angular increment using the following equation; starting at the "0" degree location for each sensing area as described below in (1).

$$TIR_x = \frac{(R1_x + R2_x) - (R1_0 + R2_0)}{2} \times \frac{10}{S}$$

(1) Where $R1_x$ and $R2_x$ are the readings at a given angular position in mV

$R1_0$ and $R2_0$ are the readings at the 0 angular position in mV

S is the sensitivity factor in V/inch or V/m (See Appendix 2)

TIR_x is the runout at a given position in ten thousandths of an inch or microns.

5.7 The runout result is determined using (1) by $TIR_{max} – TIR_{min}$ where TIR_{max} is the most positive TIR_x value and TIR_{min} is the most negative TIR_x value.

5.8 Compare maximum allowable runout from the Sulzer Balance / Runout Requirements sheet with runout result; ensure that both values are in the same units and included in the report. Note that API 610, 11th edition, paragraph 6.6.10 e) states that the maximum allowed runout is 25% of the allowed peak-to-peak vibration amplitude or 6µm (0.25 thousandths of an inch), whichever is greater. If the runout result exceeds the maximum allowable runout see section on Demagnetization correction below; otherwise document the acceptance of the result with signature and date on the report.

6 Demagnetization correction and re-examination

6.1 Check magnetism in the shaft sensing areas, it should be less than 2 gauss. If magnetism is over 2 gauss, demagnetize the probe areas to remove any magnetic interference. Recheck the combined electrical and mechanical runout. If excessive runout remains, rework the probe area(s) of the shaft by grinding and burnishing. Recheck the combined electrical-mechanical runout.

6.2 If reworking the probe area(s) fails to meet the combined electrical-mechanical runout specifications, initiate a Non-Conformance Report (NCR).

7 Reporting

7.1 The following information shall be recorded on the report form (DT-0027 or similar):

a) Serial numbers of all calibrated test equipment used with calibration due dates

b) Sulzer shaft drawing number and revision

c) Sulzer Balance / Runout Requirements sheet number with revision

d) Shaft identification (heat and/or serial number, part number)

e) Procedure and/or work instruction used with revision level

f) Test result: Total Indicated Runout and accept or reject

g) Date examination performed

h) Name of person performing examination

i) Whether the static or dynamic test method was used.

8 Post examination cleaning

8.1 After the completion of the test remove any oils using solvent or water, as appropriate. For austenitic stainless steels, the water chloride ion shall not exceed 50 ppm. Treat any exposed carbon steel to prevent rust during shipment and temporary storage.

Appendix 1: Background information

(Normative)

Table 1: Design of probe track areas on shafts

Shaft Base Material	Peripheral Surface Speed (m/sec)	Journal Bearing Running Surface	Proximity Probe Running Track	Notes
1% Cr-Mo (4140)	N/A	Base Material	Base Material	6
12% Chrome	Up to 40	Base Material	Base Material	2,4,5,6
	Over 40	Steel Sleeve or Chrome Plated	Steel Sleeve or Base Material	
17/4 PH	Up to 40	Base Material	Base Material	2,4,5,6
	Over 40	Steel Sleeve or Chrome Plated	Steel Sleeve or Base Material	
316 St. Steel 316 Edelstahl	N/A	Steel Sleeve or Chrome Plated	Steel Sleeve or Base Material	2,4,5
Nitronic 50	N/A	Steel Sleeve or Chrome Plated	Steel Sleeve or Nickel Plated	1,2,3,4,5
Duplex Alloy Duplex-Legierung	Up to 20	Steel Sleeve or Base Material	Steel Sleeve or Nickel Plated	1,2,3,4
	Over 20	Steel Sleeve or Chrome Placed		1,2,3,4,5
Monel K500	Up to 20	Base Material	Base Material	
	Over 20	Steel Sleeve or Chrome Plated	Steel Sleeve or Base Material	2,4,5

Notes:

1 Eddy current proximity probes are not compatible with Nitronic 50 and Duplex Alloy shaft materials. When proximity probes are required with such materials it is necessary to either:

a) Fit a Carbon Steel sleeve extending beneath the Inpro seal / deflector and the journal bearing running surface (see typical drawing 1-204.210.090 Part 001).

Or

b) Nickel Plate the proximity probe track (see typical drawing 1-204.210.090 Part 002).

2 An option is to shrink fit a Carbon Steel sleeve nominally 3 mm thick. By doing this it may be necessary to reduce the shaft extension diameter to the next standard size down. In all cases where this occurs, shaft stress calculations are to be carried out in accordance with Engineering Standard E10.50.1.

3 On critical duties, where reduction in the shaft extension diameter cannot be tolerated, the option of Nickel Plating the proximity probe track is to be carried out.

4 Exception to API 610 is required in instances where the proximity probe track is either sleeved or plated.

5 Chrome plated areas must be Industrial Chrome Plated in accordance with Engineering Standard E10.50.3.

6 API 610 9th edition 8.2.5.1.4 BBT 1 through BB5 requires that for shaft materials containing more than 1% Chrome and the journal speed is above 20 m/sec the shaft's journal shall be hard chrome plated, hard coated, or sleeved with carbon steel.

Sulzer takes the following exceptions to this clause:

- For AISI 4140 pump shafts

  Sulzer do not chrome plate, hard coat or sleeve the journal bearing surfaces.

  The Chrome content is only marginally above the 1% level and it is our experience that damage to the bearing from 'wire wooling' will not occur.

- For 12% Chrome and 17/4-PH pump shafts

  Sulzer hard coat, or sleeve the journal bearing surface when the journal bearing speed exceeds 40 m/sec. It is Sulzer’s experience that damage to the bearing from 'wire wooling' will not occur at surface velocities up to 40 m/sec.

  Please refer to the contractually agreed exceptions to API / Client specifications.

Appendix 2: Recommended procedure to obtain sensor sensitivity factor

(informative)

A2 Sensitivity Factor

A2.1 During the calibration of the testing apparatus, the sensitivity factor for various materials is determined. See Figure 1 for a typical set up. Install the probe into the device and adjust the gap such that the output of the voltmeter is -10.0 VDC.

A2.2 Move the target in and then out 0.010" (0.254 mm), record the voltage in the out (V_{out}) and in (V_{in}) positions. The sensitivity factor is then determined as (V_{out} – V_{in}) / 0.020 as expressed in V / inch or (V_{out} – V_{in}) / 0.508 as expressed in V / m.

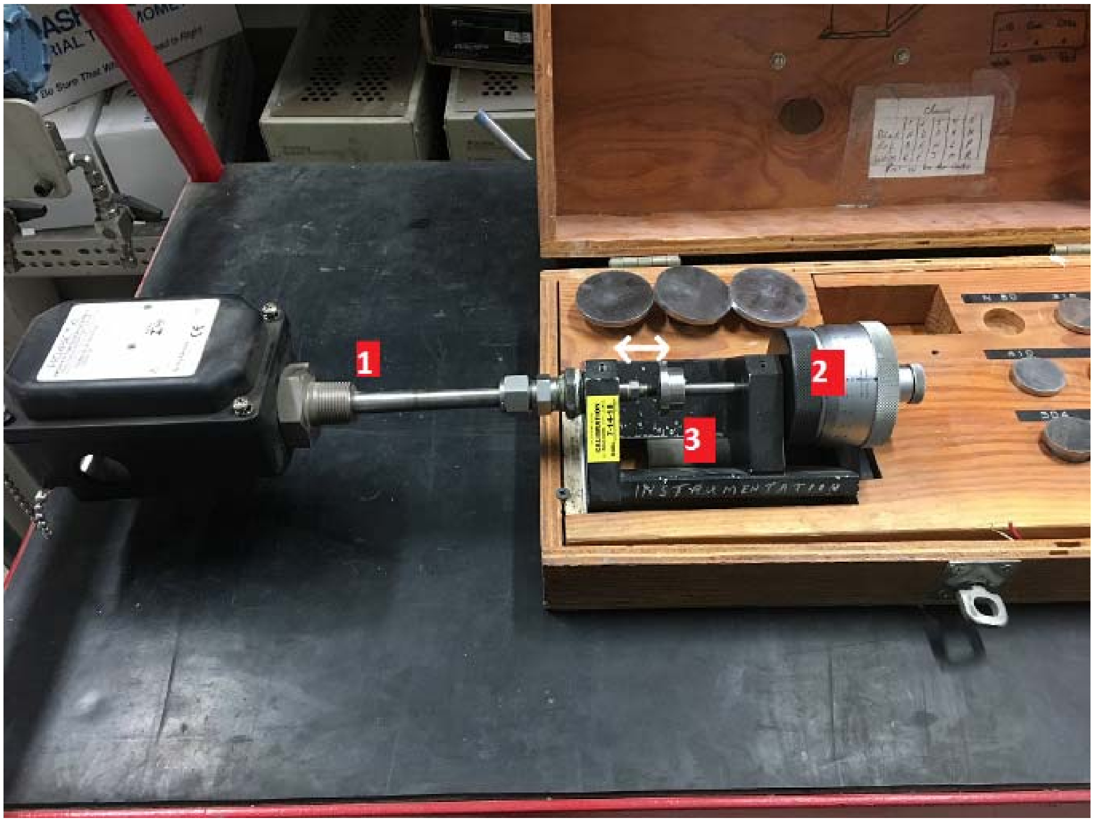

Figure 1: 1) probe; 2) dial for moving target; 3) sample target of same material as shaft