

A REVIEW OF ISO AND ANSI STANDARDS ON MACHINERY VIBRATION AND CONDITION MONITORING

by

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ISO/ANSI STANDARDS

↖ BACKGROUND

↖ ISO/ANSI RELATIONSHIP

↖ THE RELATIONSHIP BETWEEN
TECHNICAL AND QUALITY STANDARDS

↖ ACTIVITIES OF ISO/TC108

↖ CLOSURE

ORGANIZATIONS

- ✦ ISO — GENEVA TC 108
- ✦ ANSI — NEW YORK ANSI S2 COMMITTEE
- ✦ ASA — NEW YORK ACCREDITED BY ANSI TO
MANAGE TC108 AND S2
- ✦ VIBRATION INSTITUTE SUPPORTS TECHNICAL
WORK

ISO DEVELOPS STANDARDS (ISO 17024)

ANSI ACCREDITS ORGANIZATIONS TO CERTIFY PERSONNEL

VI CERTIFIES INDIVIDUALS TO ISO 18436

MOTIVATION

- ↖ MUTUAL UNDERSTANDING FOR INTERNATIONAL TRADE
- ↖ EXCHANGE OF TECHNICAL INFORMATION
- ↖ STANDARDIZE PROCEDURES, CRITERIA, AND LEVELS OF ACCEPTANCE AND CONDITION
- ↖ CONFORMITY ASSESSMENT OF CERTIFICATION BODIES AND PERSONNEL

OVERVIEW

- WORK ON ACCEPTANCE STANDARDS CONTINUES
- EMPHASIS NOW ON CONDITION MONITORING AND DIAGNOSTICS
- BEGAN WORK ON CERTIFICATION OF PERSONNEL IN 1998
- BALANCING ACTIVITY NOW MINIMAL

ISO DEVELOPMENT HISTORY

➤ ISO/TC 108

- ✓ FOUNDED CIRCA 1964 BY DR. TRENT

➤ ISO/TC 108/SC1 AND SC2

- ✓ FOUNDED CIRCA 1970 BY ED NOONAN

➤ ISO/TC 108/SC5

- ✓ FOUNDED CIRCA 1988 BY DOUG MUSTER

ISO/ANSI RELATIONSHIP

- ↖ ANSI S2 PROVIDES THE LINK FOR U.S. PARTICIPATION IN ISO/TC 108 AND ITS SUBCOMMITTEES
- ↖ VIBRATION INSTITUTE MEMBER OF S2 AND INTERESTED IN S2-09 AND S2-10
- ↖ VIBRATION INSTITUTE INVOLVED WITH TC108/SC2/SC5

PARTICIPATION

- COMPANIES, GOVERNMENT AGENCIES, AND ORGANIZATIONS MAY SEEK MEMBERSHIP IN S2 (THE U.S. TAG)
- NOMINEES TO INTERNATIONAL WORKING GROUPS MUST BE MEMBERS OF THE U.S. TAG
- FOR INFORMATION CONTACT SUSAN BLAESER (631) 390-0215 sblaeser@aip.org

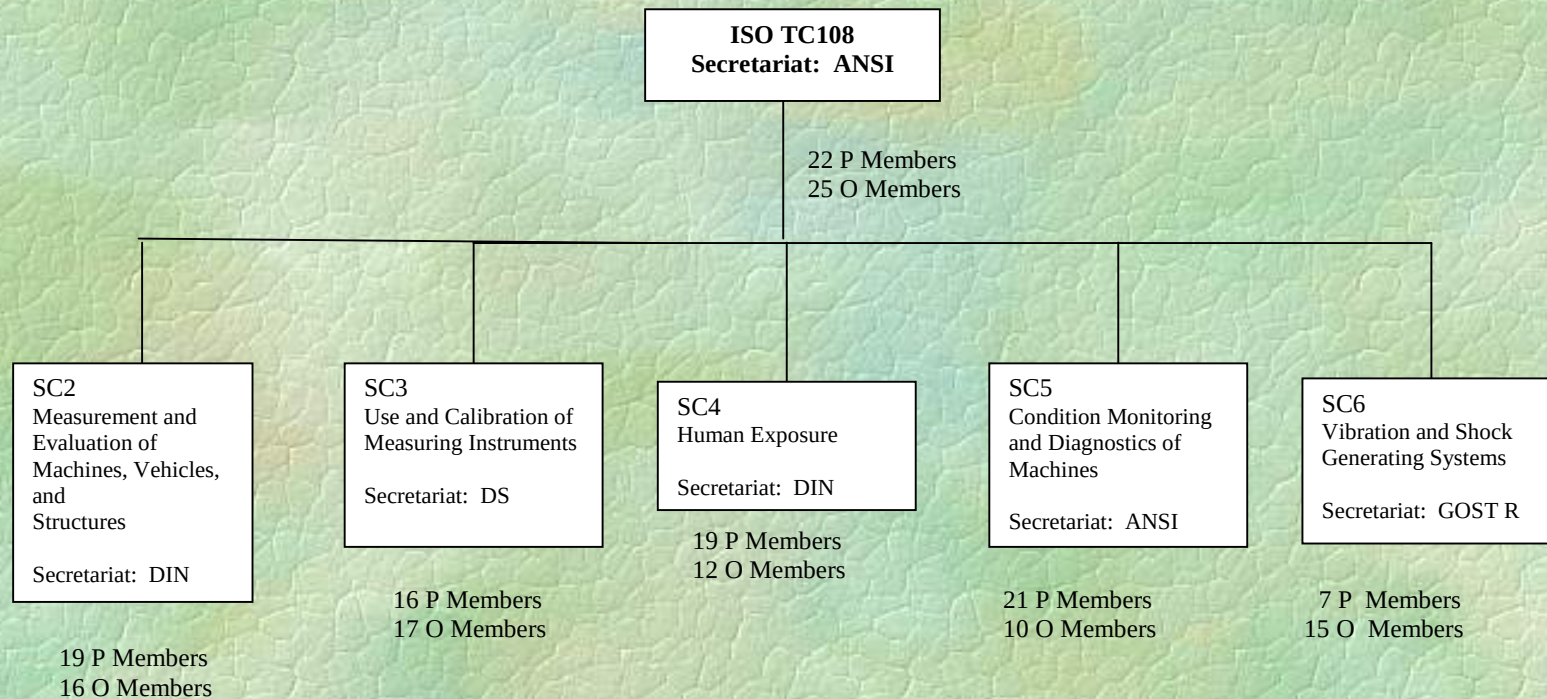
CURRENT S2 MEMBERSHIP LIST

- ✧ Acoustical Society of America
- ✧ Acquip, Inc.
- ✧ American Industrial Hygiene Association
- ✧ Association of American Railroads
- ✧ BJM Corp.
- ✧ Bruel & Kjaer Instrumentation, Inc.
- ✧ Calnetix
- ✧ Caterpillar, Inc.
- ✧ Emerson Electric - Copeland Corporation
- ✧ Endveco Corp.
- ✧ Infrared Training Center
- ✧ International Council for Machinery Lubrication
- ✧ John Deere
- ✧ Mechanical Solutions, Inc.
- ✧ MIMOSA
- ✧ National Institute of Standards & Technology
- ✧ Power Tool Institute
- ✧ Quest Technologies, Inc.
- ✧ Sandia National Labs
- ✧ Shock and Vibration Information and Analysis Center
- ✧ Scantek, Inc.
- ✧ Schenck Trebel Corp.
- ✧ **Society for Machinery Failure Prevention Technology**
- ✧ Spyglass Company
- ✧ U. S. Air Force
- ✧ U.S. Department of Transportation
- ✧ U.S. Naval Sea Systems Command
- ✧ U.S. Naval Surface Warfare Center – Carderock Division
- ✧ Naval Surface Warfare Center, Crane Division
- ✧ T-Solutions, Inc.
- ✧ UE Systems, Inc.
- ✧ **Vibration Institute**
- ✧ Waukesha Magnetic Bearings

RELATIONSHIP BETWEEN TECHNICAL AND QUALITY STANDARDS

- ↖ ADOPTION OF TECHNICAL STANDARDS AND PROCEDURES IN ISO 9000 QUALITY VOLUNTARY BUT RECOMMENDED
- ↖ TECHNICAL STANDARDS GIVE QUALITY STANDARD CREDIBILITY
- ↖ QUALITY STANDARD IS ENHANCED THROUGH USE OF SELECTED TECHNICAL NORMS

ORGANIZATION OF ISO TC108



*Subcommittee

SC1 BALANCING (now TC 108 Working Group)

- **BALANCE QUALITY OF MACHINES WITH
RIGID AND FLEXIBLE ROTORS**
- **BALANCING MACHINES INCLUDING
ENCLOSURES**

SC1 PRINCIPAL DOCUMENTS

➤ ISO 1925

- ✓ MECHANICAL VIBRATION – BALANCING VOCABULARY

➤ ISO 1940

- ✓ MECHANICAL VIBRATION – BALANCE QUALITY REQUIREMENTS FOR RIGID ROTORS

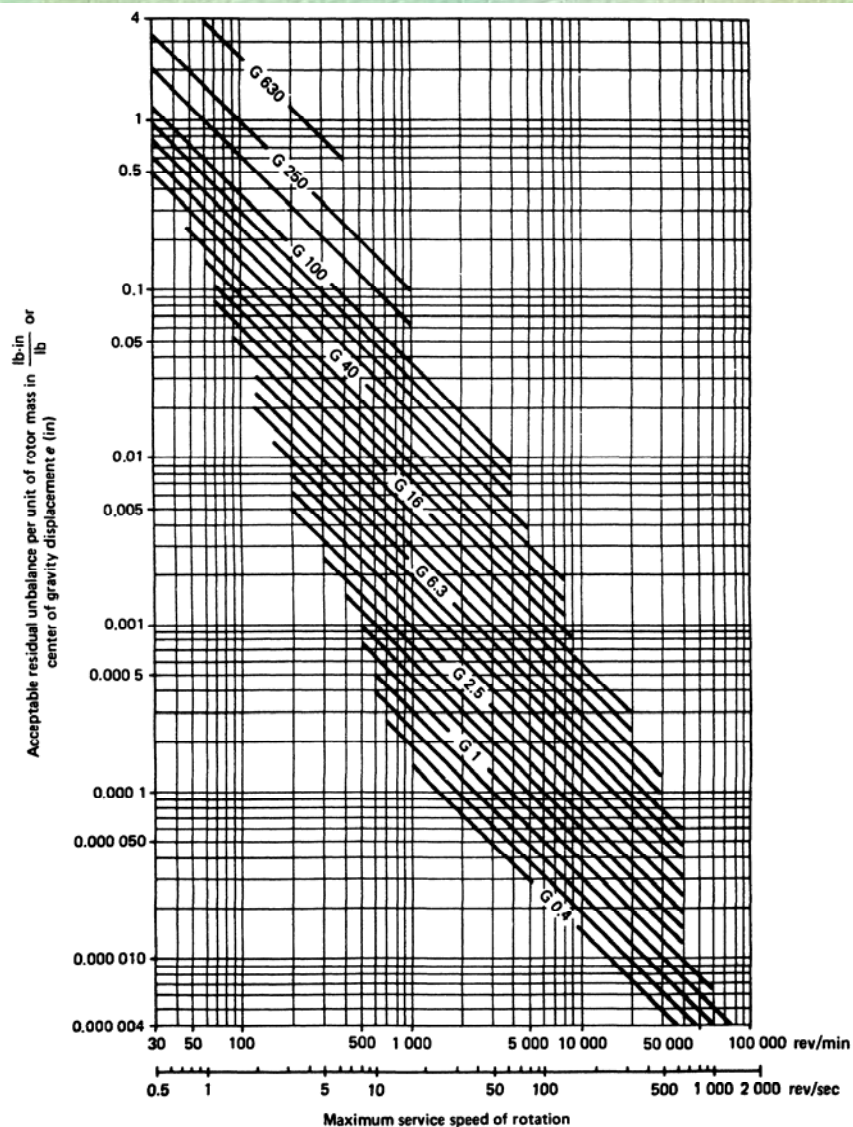
➤ ISO 11342

- ✓ FOR MECHANICAL BALANCING OF FLEXIBLE ROTORS

➤ ISO 20806

- ✓ IN-SITU BALANCING OF ROTORS

ISO 1940 (ANSI S2-19)– RIGID ROTOR BALANCING



ISO 1940 BALANCING

Table 1. Balance quality grades for various groups of representative rigid rotors

BALANCE QUALITY GRADES G	$E_0^{A,B}$ (MM/SEC)	ROTOR TYPES—GENERAL EXAMPLES
G 40	40	Car wheels, wheel rims, wheel sets, drive shafts. Crankshaft-drives of elastically mounted fast four-cycle engines (gasoline or diesel) with six or more cylinders. ^d Crankshaft-drives for engines of cars, trucks, and locomotives.
G 16	16	Drive shafts (propeller shafts, cardan shafts) with special requirements. Parts of crushing machinery. Parts of agricultural machinery. Individual components of engines (gasoline or diesel) for cars, trucks, and locomotives. Crankshaft-drives of engines with six or more cylinders under special requirements. Slurry or dredge pump impeller.
G 6.3	6.3	Parts or process plant machines. Marine main turbine gears (merchant service). Centrifuge drums. Fans. Assembled aircraft gas turbine rotors. Fly wheels. Pump impellers. Machine-tool and general machinery parts. Normal electrical armatures. Individual components of engines under special requirements.
G 2.5	2.5	Gas and steam turbines, including marine main turbines (merchant service). Rigid turbo-generator rotors. Rotors. Turbo-compressors. Machine-tool drives. Medium and large electrical armatures with special requirements. Small electrical armatures. Turbine driven pumps.
G 1	1	Tape recorder and phonograph (gramophone) drives. Grinding-machine drives. Small electrical armatures with special requirements.
G 0.4	0.4	Spindles, disks, and armatures of precision grinders. Gyroscopes.

SC2 MEASUREMENT AND EVALUATION OF MACHINES, VEHICLES, AND STRUCTURES

- MACHINE VIBRATION ACCEPTANCE TESTING ON SHAFTS AND PEDESTALS
- VIBRATION CONDITION MONITORING AND DIAGNOSTIC PROCEDURES, ANALYSIS, AND DIAGNOSTICS

SC2 PRINCIPAL DOCUMENTS

➤ ISO 7919

- ✓ MEASUREMENT OF ROTATING SHAFTS AND EVALUATION CRITERIA – PARTS 1-5

➤ ISO 10816

- ✓ EVALUATION OF MACHINE VIBRATIONS BY MEASUREMENT OF NON-ROTATING SURFACES – PARTS 1-6

ISO 10816 SEISMIC VIBRATIONS

rms velocity ranges of vibration severity	vibration severity* for separate classes of machines			
in./sec.	Class I	Class II	Class III	Class IV
0.01	A	A	A	A
0.02				
0.03				
0.04	B	B	B	B
0.07	C	C	C	C
0.11	D	D	D	D
0.18				
0.28				
0.44				
0.71				
1.10				
1.77				

*The letters A, B, C, and D represent machine vibration quality grades, ranging from good (A) to unacceptable (D).

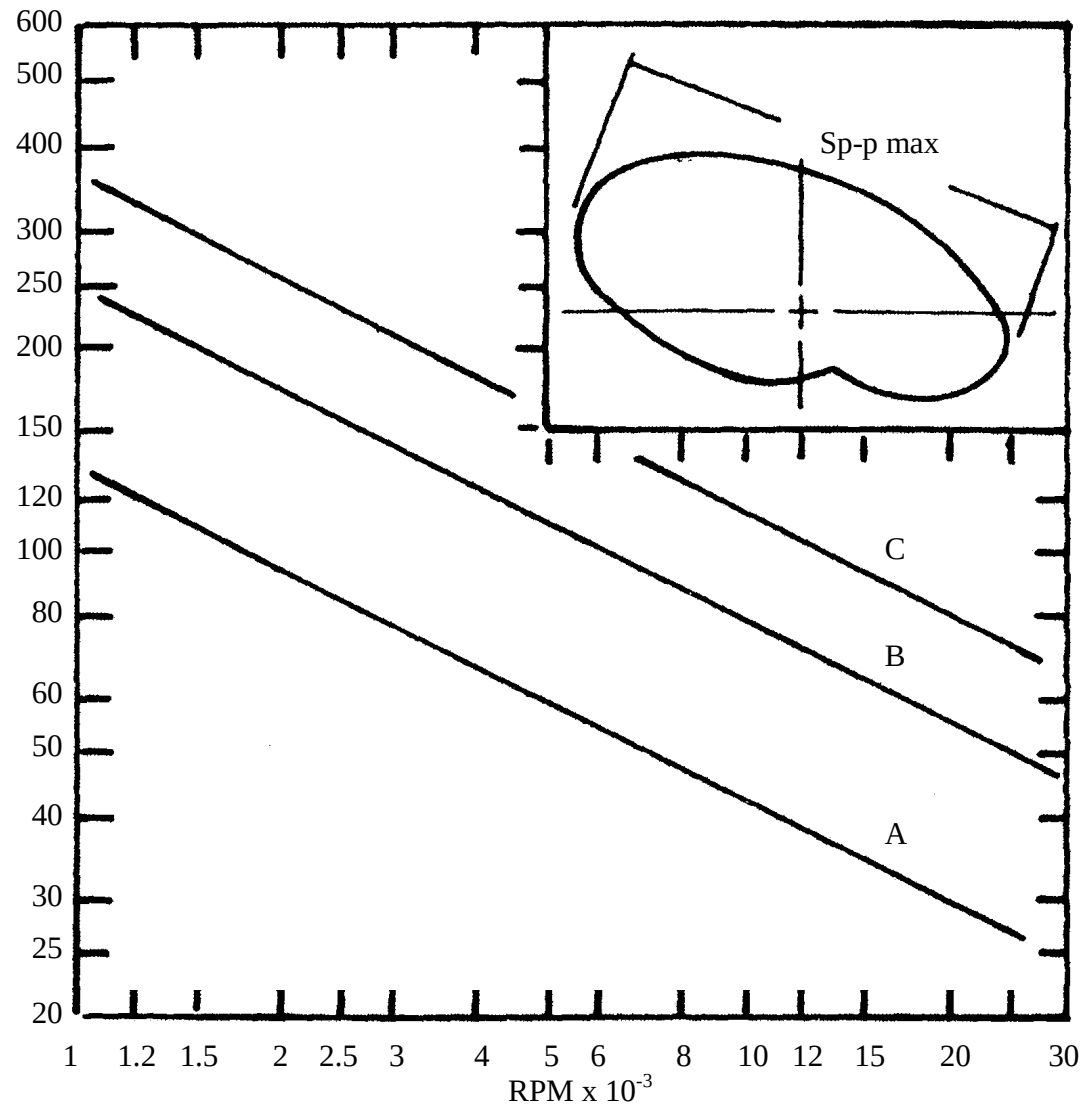
Class I. Individual components, integrally connected with the complete machine in its normal operating conditions (i.e., electric motors up to 15 kilowatts, 20 HP).

Class II Medium-sized machines (i.e., 15- to 75-kilowatt electric motors and 300 kilowatt engines on special foundations).

Class III. Large prime movers mounted on heavy, rigid foundations.

Class IV. Large prime movers mounted on relatively soft, lightweight structures.

ISO 7919 SHAFT VIBRATIONS



ISO 7919 SHAFT VIBRATIONS

A = limit of good vibration performance:

$$Sp - p \text{ max A in } \mu\text{m} = 4200 / \sqrt{n \text{ in RPM}}$$

B = limit for alarm release:

$$Sp - p \text{ max B in } \mu\text{m} = 7875 / \sqrt{n \text{ in RPM}}$$

C = limit for trip

$$Sp - p \text{ in max C in } \mu\text{m} = 11550 / \sqrt{n \text{ in RPM}}$$

Applicable for rotational speed from about 1000 RPM to 30000 RPM;
25.4 $\mu\text{m}/\text{mil}$

SC5 – CONDITION MONITORING AND DIAGNOSTICS OF MACHINES

- **CONDITION MONITORING USING VIBRATION, OIL, THERMOGRAPHY AND ELECTRICAL PARAMETERS**
- **DATA INTERPRETATION AND DIAGNOSTIC TECHNIQUES**
- **MACHINE PROGNOSTICS**
- **FORMATS AND METHODS FOR COMMUNICATING, PRESENTING, AND DISPLAYING INFORMATION AND DATA**
- **TRAINING AND CERTIFICATION OF PERSONNEL**

ORGANIZATION OF TC108/SC5

SC5 - Secretariat: ANSI

WG1 Terminology

S: ANSI

WG2 Data Interpretation and Diagnostic Techniques

S: AFNOR

WG4 Tribology Based Monitoring and Diagnostics

S: ANSI

WG5 Prognostics

S: SAI

WG6 Formats and Methods for Communicating, Presenting, and
Displaying Relevant Information and Data

S: ANSI

ORGANIZATION OF TC108/SC5 (cont.)

SC5 - Secretariat: ANSI

WG7 Training and Certification of Condition Monitoring
and Diagnostics Personnel
S: ANSI

WG8 Condition Monitoring and Diagnostics of Machines
S: BSI

WG10 Condition Monitoring and Diagnostics of
Electrical Equipment S: IPQ

WG11 Thermal Imaging
S: SA

WG14 Acoustic Techniques
S: BSI

SC5 – PRINCIPAL DOCUMENTS

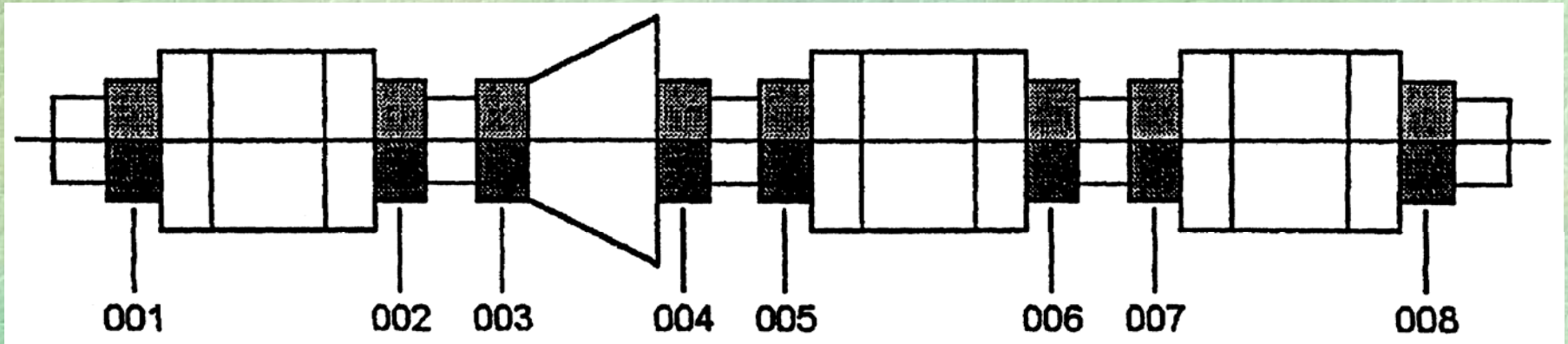
- ISO 13372
 - ✓ TERMINOLOGY FOR THE FIELDS OF CONDITION MONITORING AND DIAGNOSTICS OF MACHINES
- ISO 13379
 - ✓ DATA INTERPRETATION AND DIAGNOSTIC TECHNIQUES FOR MACHINE CONDITION – GENERAL GUIDELINES
- ISO 13380
 - ✓ PERFORMANCE MONITORING AND DIAGNOSTICS
- ISO 17359
 - ✓ CONDITION MONITORING AND DIAGNOSTICS OF MACHINES – GENERAL GUIDELINES
- ISO 18436
 - ✓ TRAINING AND CERTIFICATION OF CONDITION MONITORING PERSONNEL:
 - PART I – REQUIREMENTS FOR CERTIFYING BODIES
 - PART II – VIBRATION ANALYSIS
 - PART III – REQUIREMENTS FOR TRAINING BODIES

ISO 13373 VIBRATION CONDITION MONITORING GENERAL PROCEDURES

- TYPES OF PROGRAMS
- MEASUREMENTS
 - ✓ SEISMIC
 - ✓ SHAFT
- TRANSDUCERS
- DATA PRESENTATION
- TRENDING
- ANALYSIS
 - ✓ ANNEX A – TYPES AND LOCATIONS OF MEASUREMENTS
 - ✓ ANNEX B – EQUIPMENT KNOWLEDGE
 - ✓ ANNEX C – EXCITATION
 - ✓ ANNEX D – MEASUREMENT LOCATIONS

ANALYSIS

MEASUREMENT LOCATIONS



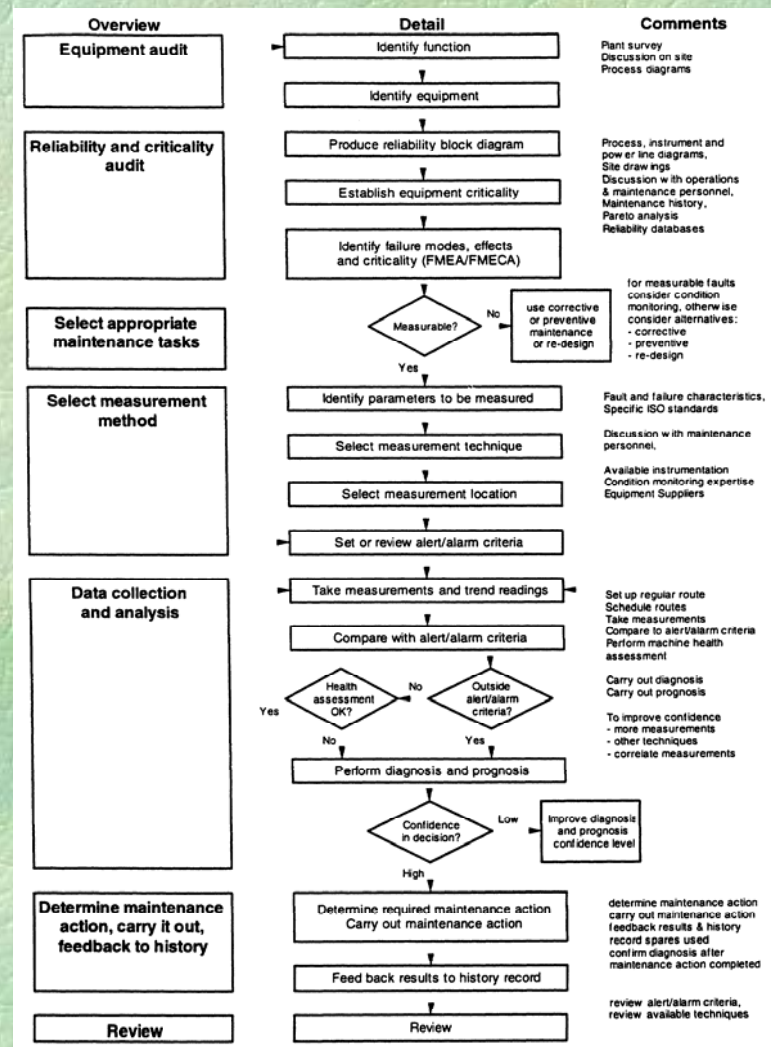
Bearing Housing Designation Convention
when Both Ends of the Driver are Coupled

ISO 17359 CONDITION MONITORING AND DIAGNOSTICS OF MACHINES – GENERAL GUIDELINES

- **CRITICALITY ANALYSIS**
- **MEASUREMENT METHODS**
- **MEASUREMENT LOCATIONS**
- **DATA COLLECTION AND ANALYSIS**
- **MAINTENANCE ACTION**

ISO 17359

CONDITION MONITORING PROCEDURE FLOWCHART



ISO 13379 – DATA INTERPRETATION AND DIAGNOSTIC TECHNIQUES

- **CONDITION MONITORING SETUP AND
DIAGNOSTICS SETUP**
- **FAILURE MODE SYMPTOMS**
- **ELEMENTS USED FOR DIAGNOSTICS**
- **DIAGNOSTIC APPROACHES**

ISO 13380 – PERFORMANCE MONITORING AND DIAGNOSTICS

- **MONITORED PARAMETERS**
- **MEASUREMENT PROCEDURE**
- **FAULT DIAGNOSIS**
- **MONITORING FAULT CHART**

ISO 13380 – FAULT-SYMPTOM CHART FOR GENERATORS

Machine type: Electric generators	Symptom or parameter change												
Fault	Current	Voltage	Resistance	Partial discharge	Power	Torque	RF (Radio Frequency) emissions	Vibration	Temperature	Coast down	Axial flux	Oil debris	Cooling gas
Rotor windings	.							.	.		.		.
Stator windings	.							.	.		.		.
Eccentric rotor	.							.			.		
Brush(es) fault	.	.			.	.	.		.				
Bearing damage						.		.	.	.		.	
Insulation deterioration	.	.	.	.									.
Loss of output power phase	.	.						.					
Unbalance								.					
Misalignment								.					

• Indicates symptom may occur or parameter may change if fault occurs.

[illegible]

Machine type: Electric generators	Symptom or parameter change												
Fault	Current	Voltage	Resistance	Partial discharge	Power	Torque	RF (Radio Frequency) emissions	Vibration	Temperature	Coast down	Axial flux	Oil debris	Cooling gas
Rotor windings	•							•	•		•		•
Stator windings	•							•	•		•		•
Eccentric rotor	•							•			•		
Brush(es) fault	•	•			•	•	•		•				
Bearing damage						•		•	•	•		•	
Insulation deterioration	•	•	•	•									•
Loss of output power phase	•	•						•					
Unbalance								•					
Misalignment								•					

• Indicates symptom may occur or parameter may change if fault occurs.

ISO 18436 – TRAINING AND CERTIFICATION TOPICS

- VIBRATION
- OIL ANALYSIS
- THERMOGRAPHY
- LUBRICATION
- ACOUSTIC EMISSION
- ELECTRIC CURRENT ANALYSIS
- CONDITION MONITORING

ISO 18436 – TRAINING AND CERTIFICATION OF CONDITION MONITORING PERSONNEL

**PART I REQUIREMENTS FOR
CERTIFYING BODIES**

PART II VIBRATION ANALYSIS

**PART III REQUIREMENTS FOR TRAINING
BODIES**

PART IV LUBRICATION

PART V THERMOGRAPHY

CONDITION MONITORING & DIAGNOSTICS OF MACHINES — TRAINING AND CERTIFICATION

↖ VIBRATION ANALYSIS (published)

↖ LUBRICATION ANALYSIS AND
TECHNIQUES (in development)

↖ LUBRICANT LABORATORY ANALYST/
TECHNICIAN (planned)

↖ CONDITION MONITORING SPECIALISTS (in
development)

↖ THERMOGRAPHY (in development)

↖ ACOUSTIC EMISSION (in development)

CLASSIFICATION OF PERSONNEL

- VIBRATION ANALYST: CATEGORY I
- VIBRATION ANALYST: CATEGORY II
- VIBRATION ANALYST: CATEGORY III
- VIBRATION ANALYST: CATEGORY IV

CATEGORY I

- ENTRY LEVEL PERSONNEL WHO HAVE LITTLE EXPERIENCE AND TRAINING

CATEGORY II

- Individuals certified to perform industrial machinery vibration measurements and basic vibration analysis using single-channel measurements, with or without phase trigger signals, according to established and recognized procedures.

CATEGORY III

- Individuals certified to perform and/or direct machinery vibration measurements and analysis according to established and recognized procedures.

CATEGORY IV

- Individuals certified to perform and/or direct all types of machinery vibration measurements and analysis.

ELIGIBILITY FOR EXAMINATION

- EDUCATION (RECOMMENDATIONS)
 - ✓ VIBRATION ANALYST: CATEGORY I & II
 - HIGH SCHOOL
 - ✓ VIBRATION ANALYST: CATEGORY III & IV
- TWO OR MORE YEARS OF MECHANICAL TECHNOLOGY OR MECHANICAL ENGINEERING TRAINING (CUMULATIVE REQUIRED HOURS)*

I	II	III	IV
32	70	110	174

*can be documented self training

- EXPERIENCE (CUMULATIVE REQUIRED MONTHS)

I	II	III	IV
12	24	36	60

EXAMINATION DETAILS

CLASSIFICATION	NUMBER OF QUESTIONS	TIME (HOURS)	PASSING GRADE (%)
CATEGORY I	48	2	75
CATEGORY II	100	3	75
CATEGORY III	100	4	75
CATEGORY IV	60	5	75

ANNEX A

TOPICS OF STUDY FOR CERTIFICATION

- ↖ Technical Area
- ↖ Detailed Topic List
- ↖ Category Accountability

Annex B

(normative)

Applicable International Standards

ISO reference	Category			
	I	II	III	IV
ISO 10816-2, <i>Mechanical vibration — Evaluation of machine vibration by measurements on non-rotating parts — Part 2: Land-based steam turbines and generators in excess of 50 MW with normal operating speeds of 1 500 r/min, 1 800 r/min, 3 000 r/min and 3 600 r/min</i>		•	•	•
ISO 10816-3, <i>Mechanical vibration — Evaluation of machine vibration by measurements on non-rotating parts — Part 3: Industrial machines with nominal power above 15 kW and nominal speeds between 120 r/min and 15 000 r/min when measured in situ</i>		•	•	•
ISO 10816-4, <i>Mechanical vibration — Evaluation of machine vibration by measurements on non-rotating parts — Part 4: Gas turbine driven sets excluding aircraft derivatives</i>		•	•	•
ISO 10816-5, <i>Mechanical vibration — Evaluation of machine vibration by measurements on non-rotating parts — Part 5: Machine sets in hydraulic power generating and pumping plants</i>		•	•	•
ISO 10816-6, <i>Mechanical vibration — Evaluation of machine vibration by measurements on non-rotating parts — Part 6: Reciprocating machines with power ratings above 100 kW</i>		•	•	•
ISO 11342, <i>Mechanical vibration — Methods and criteria for the mechanical balancing of flexible rotors</i>				•
ISO 13372, <i>Condition monitoring and diagnostics of machines — Vocabulary</i>	•	•	•	•
ISO 13373-1, <i>Condition monitoring and diagnostics of machines — Vibration condition monitoring — Part 1: General procedures</i>	•	•	•	•
ISO 13379, <i>Condition monitoring and diagnostics of machines — General guidelines on data interpretation and diagnostics techniques</i>			•	•
ISO 14694, <i>Industrial fans — Specifications for balance quality and vibration levels</i>	•	•	•	•
ISO 14695, <i>Industrial fans — Method of measurement of fan vibration</i>			•	•
ISO 17359, <i>Condition monitoring and diagnostics of machines — General guidelines</i>	•	•	•	•
ISO 18436-1, <i>Condition monitoring and diagnostics of machines — Requirements for training and certification of personnel — Part 1: Requirements for certifying bodies and the certification process</i>				•

CLOSURE

ISO/ANSI PROCESS PROVIDES:

1. OPPORTUNITY FOR EXCHANGE OF TECHNICAL IDEAS AND INFORMATION
2. IDENTIFICATION OF TECHNICAL NEEDS
3. STANDARDIZATION OF PROCEDURES AND REQUIREMENTS