



▶▶ Under the patronage of **H.E. Dr. Abdullah Belhaif Al Nuaimi** - Minister of Infrastructure Development



▶▶ 17<sup>th</sup> Edition

—  
International Operations & Maintenance Conference in the Arab Countries

**19, 20, 21 NOV 2019**

Le Meridien Dubai Hotel  
& Conference Centre  
United Arab Emirates

Under the Theme:

**Enhancing Maintenance  
Through Big Data Management**

▶▶ **ISO Standards Update**  
**Update on ISO Standards in  
Condition Monitoring and  
Vibration**

# ►► Introduction

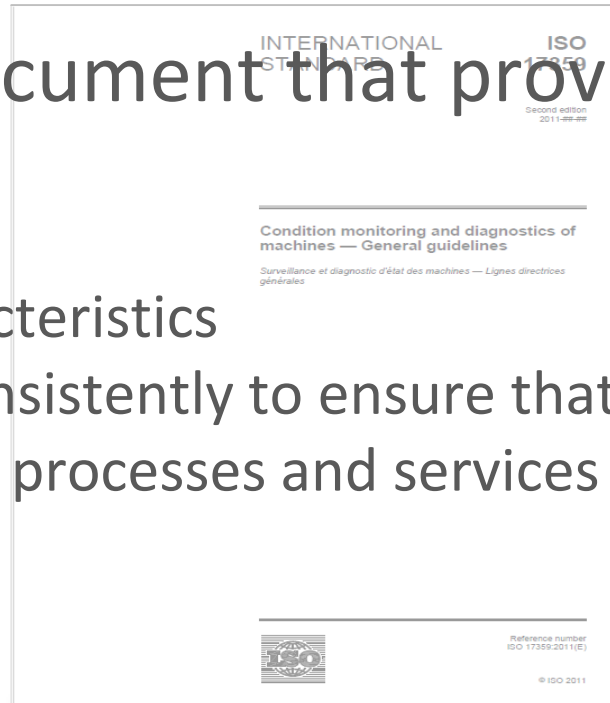
- This paper presents an update on the progress in International Standards on developing & maintaining Condition Monitoring (CM) Standards, and Standards related to CM techniques including:
  - vibration
  - infra-red thermography
  - acoustic emission
  - ultrasonics
  - tribology and lubrication

# ▶▶ ISO Committees

- CM and VM Standards are within the scope of ISO Technical Committee 108 (ISO/TC108)
- There are over 50 VM Standards and 25 CM Standards produced by this committee
  - Since 2010, over **90** documents have been issued revised or renumbered in ISO/TC108's complete portfolio
  - Currently **15** are in development or review
  - This paper gives the latest status of a selection of these documents

# ►► What is a standard?

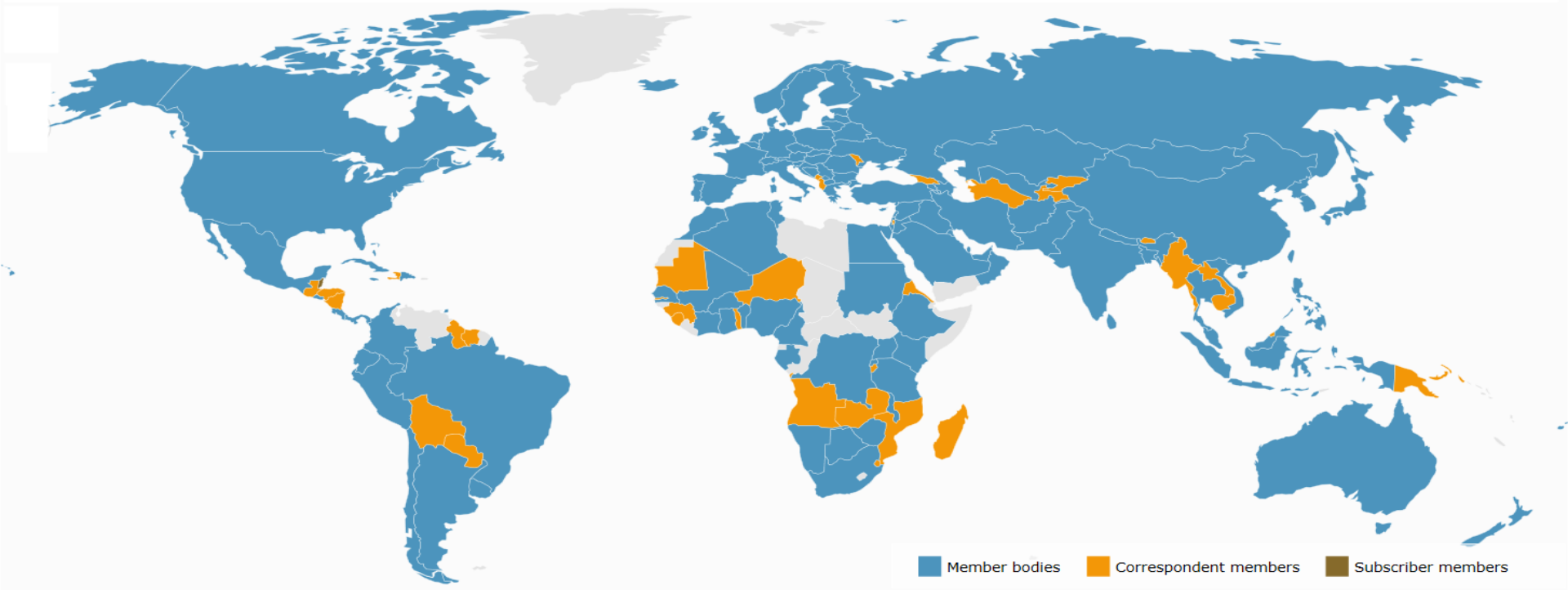
- A standard is a document that provides:
  - Requirements
  - Specifications
  - Guidelines or Characteristics
  - that can be used consistently to ensure that materials, products, processes and services are fit for their purpose



# ▶▶ Where Standards come from

- Member countries, through their National Standards organisations provide:
  - technical expertise
  - committee membership
  - propose new standards
  - produce new standards
  - review existing standards
    - <https://www.iso.org/members.html>

# ▶▶ ISO Member Countries



# ▶▶ ISO Member Categories

- Full members (or member bodies) (120)
  - influence ISO standards development and strategy by participating and voting in ISO technical and policy meetings.
  - sell and adopt ISO International Standards nationally.
- Correspondent members (40)
  - observe the development of ISO standards and strategy by attending ISO technical and policy meetings as observers
  - can sell and adopt ISO International Standards nationally
- Subscriber members (4)
  - keep up to date on ISO's work but cannot participate in it
  - do not sell or adopt ISO International Standards nationally

[http://www.iso.org/iso/historical\\_record\\_of\\_iso\\_membership\\_1947\\_to\\_today.pdf](http://www.iso.org/iso/historical_record_of_iso_membership_1947_to_today.pdf)

# ▶▶ Examples of ISO Full Members

Country	Body	Country	Body	Country	Body
Argentina	IRAM	Hong Kong	ITCHKSAR	Poland	PKN
Australia	SA	Hungary	MSZT	Portugal	IPQ
Austria	ASI	India	BIS	Romania	ASRO
Belgium	NBN	Indonesia	BSN	Russian Federation	GOST R
Brazil	ABNT	Islamic Republic of Iran	ISIRI	Saudi Arabia	SASO
Bulgaria	BDS	Ireland	NSAI	Serbia	ISS
Canada	SCC	Israel	SII	Slovakia	UNMS SR
China	SAC	Italy	UNI	South Africa	SABS
Croatia	HZN	Japan	JISC	Spain	UNE
Cuba	NC	Kenya	KEBS	Sri Lanka	SLSI
Czech Republic	UNMZ	Republic of Korea	KATS	Sweden	SIS
Denmark	DS	Malaysia	DSM	Switzerland	SNV
Egypt	EOS	Mongolia	MASM	Thailand	TISI
Finland	SFS	Netherlands	NEN	Turkey	TSE
France	AFNOR	New Zealand	NZSO	Ukraine	DSTU
Germany	DIN	Norway	SN	United Kingdom	BSI
Greece	NQIS ELOT	Pakistan	PSQCA	United States	ANSI

- Member Countries all contribute to the growing portfolio of documents and provide support and input into ISO Technical Committee work



## ▶▶ ISO today

- ISO has published over **22,600** International Standards (at September 2019)
  - <https://www.iso.org/standards.html>
- ISO Standards on Vibration, Shock and Condition Monitoring are managed by:
  - ISO Technical Committee 108 – Mechanical vibration and shock and condition monitoring (ISO/TC108)
  - ISO/TC108 has a current portfolio of **185** documents
  - [http://www.iso.org/iso/home/standards\\_development/list\\_of\\_iso\\_technical\\_committees.htm](http://www.iso.org/iso/home/standards_development/list_of_iso_technical_committees.htm)

## ▶▶ **Extract from ISO/TC 108's Business Plan**

- Mechanical vibration, shock and condition monitoring affects virtually every aspect of human endeavour
- This includes human health and safety, machines, vehicles (air, sea, and land) and stationary structures
  - Extract from ISO Business Plan
  - Re-affirmed: 24 February 2015

## ▶▶ **ISO TC 108 Scope**

- Standardization in the fields of mechanical vibration and shock and the effects of vibration and shock on humans, machines, vehicles (air, sea, land and rail) and stationary structures, and of the condition monitoring of machines and structures, using multidisciplinary approaches

# ▶▶ ISO TC 108 Areas of Interest

- Terminology for Vibration, Shock & CM
- Measurement, Analysis & Evaluation of Vibration & Shock
- Active & Passive Control Methods for Vibration & Shock
- Evaluation of the Effects of Vibration & Shock on Humans, Machines, Vehicles, Stationary Structures & Sensitive Equipment
- Vibration & Shock Instrumentation
- Condition Monitoring of Machines
- Training and Certification of Personnel

# ▶▶ UK Participation in ISO/TC 108

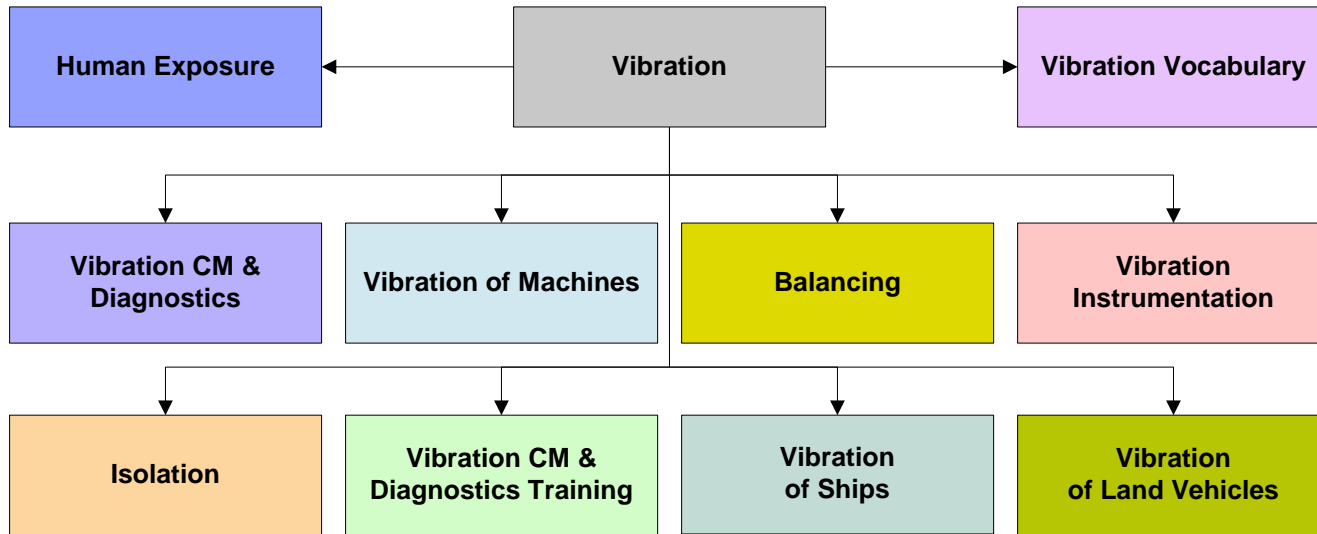
- BSI GME 21 – Mechanical vibration, shock and condition monitoring
  - Shadows: ISO/TC 108
- GME/21/1 Mechanical vibration, shock and condition monitoring - Vibration and Shock terminology
- GME/21/2 Mechanical vibration, shock and condition monitoring - Vibration and shock measuring instruments and testing equipment
  - Shadows ISO/TC108/SC6 – Vibration and shock generating systems
- GME/21/3 Whole body vibration and shock
  - GME/21/3/1 Structural dynamics and ground borne noise and vibration - Prediction, measurement assessment and evaluation
- GME/21/5 Vibration of machines, vehicles and structures
  - Shadows ISO/TC108/SC2 – Measurement and evaluation of mechanical vibration and shock as applied to machines, vehicles and structures
- GME/21/6 Human exposure to mechanical vibration and shock
  - Shadows ISO/TC108/SC4 – Human exposure to mechanical vibration and shock
- GME/21/7 Mechanical vibration, shock and condition monitoring - Condition monitoring
  - Shadows ISO/TC108/SC5 – Condition monitoring and diagnostics of machine systems

## ▶▶ ISO Vibration Standards

- ISO Vibration Standards are managed either directly at Committee Level by ISO/TC 108 (e.g. WG31 – Balancing) or by ISO/TC 108 sub-committees
- ISO/TC 108/SC 2 has issued **53** International Standards relating to Machine Vibration and Shock
- Currently **11** are in development or review

# ►► Overview of Vibration Standards

- The subject areas of Vibration International Standards useful to Vibration Analysts are shown below.
  - Also see the ISO On-line Browsing Platform: <https://www.iso.org/obp>



# ▶ Selected Vibration Standards (1 of 3)

Vibration of Machines	
<b>ISO 10816 series (Casing Vib)</b> Mechanical vibration - Evaluation of machine vibration by measurements on non-rotating parts Part 3: Industrial machines >15kW Part 6: Recip m/c >100kW Part 7: Rotodynamic pumps Part 21: Onshore wind turbines with gbx (TC108/SC2)	<b>ISO 8528-9</b> Recip internal combustion engine driven AC gen sets - Pt 9: Meas & eval of mech vib (TC70)
<b>ISO 7919 series (Shaft Vib)</b> Mech. vib. of non-recip m/c's - Meas on rotating shafts & evaluation criteria Part 3: Coupled Industrial m/c (TC108/SC2)	<b>ISO 14694</b> Industrial fans - Spec for balance quality & vibration levels (TC117)
<b>ISO 20816 series</b> Mechanical vibration - Measurement & evaluation of machine vibration Part 1: General guidelines † Part 2: Gas & steam turbo gen > 40MW † Part 4: Gas turbines > 3MW † Part 5: Hydraulic power gen † Part 8: Reciprocating compressors † Part 9: Gear Units (DIS under development) (TC108/SC2)	<b>ISO 14695</b> Industrial fans - Method of measurement of fan vibration (TC117)
	<b>ISO 14839 series</b> Mechanical vibration - Vibration of rotating machinery equipped with active magnetic bearings Part 1: Vocabulary Part 2: Evaluation of vibration Part 3: Evaluation of stability margin Part 4: Technical guidelines (TC108/SC2)

- ISO 10816 and ISO 7919 are being combined into parts of a new ISO 20816 series
- Recent changes:
  - ISO 2041 reissued 2018
  - ISO 14839-1 reissued 2018
  - ISO 20816-4 issued 2018
    - superseded ISO 10816-4 & ISO 7919-4
  - ISO 20816-5 issued in 2018
    - superseded ISO 10816-5 & ISO 7919-5
  - ISO 20816-8 issued in 2018
    - superseded ISO 10816-8



# ► Selected Vibration Standards (2 of 3)

## Balancing

ISO 21940-1 (ISO 19499)  
Mechanical vibration - Rotor balancing - Part 1: Introduction (TC108/SC2)

ISO 21940-2 (ISO 1925)  
Mechanical vibration - Rotor balancing - Part 2: Vocabulary (TC108/SC2)

ISO 21940-11 (ISO 1940-1)  
Mech. vib. - Bal quality req for rotors in a const (rigid) state - Pt 1: Spec & ver. of bal tolerances (TC108/SC2)

ISO 21940-12 (ISO 11342)  
Mech. vib. - Methods & criteria for the mech balancing of flexible rotors (TC108/SC2)

ISO 21940-13 (ISO 20806)  
Mech. vib - Rotor bal - Pt 13: Criteria & safeguards for the in-situ bal of medium & large rotors (TC108/SC2)

ISO 21940-14 (ISO 1940-2)  
Mech. vib. - Rotor balancing - Pt 14: Proc. for assessing balance errors (TC108/SC2)

ISO 21940-21 (ISO 2953)  
Mech. vib. - Rotor balancing - Pt 21: Description & evaluation of balancing machines (TC108/SC2)

ISO 21940-23 (ISO 7475)  
Mech. vib. - Rotor bal. - Pt 23: Bal. m/c - Enc. & other prot. meas'rs for the meas'g sys (TC108/SC2)

ISO 21940-31 (ISO 10814)  
Mech. vib. - Susceptibility & sensitivity of machines to unbalance (TC108/SC2)

ISO 21940-32 (ISO 8821)  
Mech. vib. - Rotor balancing - Pt 32: Shaft & fitment key convention (TC108/SC2)

- The Balancing Standards have all become parts of the ISO 21940 series
- Recent changes:
  - ISO 21940-1 issued 2019
    - Superseded ISO 19499
  - ISO 21940-2 issued 2017
    - Superseded ISO 1925
  - ISO 21940-11 issued 2016
    - Superseded ISO 1940-1
  - ISO 21940-12 issued 2016
    - Superseded ISO 11342

# ▶ Selected Vibration Standards (3 of 3)

## CM & Diagnostics

ISO 13373-1  
Vib. CM - Part 1: General  
procedures (TC108/SC2)

ISO 13373-2  
Vib. CM - Part 2: Processing  
analysis & presentation of vibration  
data (TC108/SC2)

ISO 13373-3  
Vib. CM - Part 3: Guidelines for  
vibration diagnosis  
(TC108/SC2 & SC5)

ISO/CD 13373-4  
Vib. CM - Part 4: Diag tech for gas &  
steam turb with fluid-film bearings  
(TC108/SC2 & SC5)

ISO/DIS 13373-5  
Vib. CM - Part 5: Diagnostic  
techniques for fans and blowers  
(TC108/SC2 & SC5)

ISO 13373-7  
Vib. CM - Part 7: Diag. techniques  
for m/c sets in hyd. power gen. and  
pump-storage plants (TC108/SC2 & SC5)

ISO 13373-9  
Vib. CM - Part 9: Diagnostic  
techniques for electric motors  
(TC108/SC2 & SC5)

- Vibration CM Standards are managed by ISO/TC 108/SC 2
- The following were published in 2017
  - ISO 13373-7 Diagnostics of Hydro Plant
  - ISO 13373-9 Diagnostics of Electric Motors

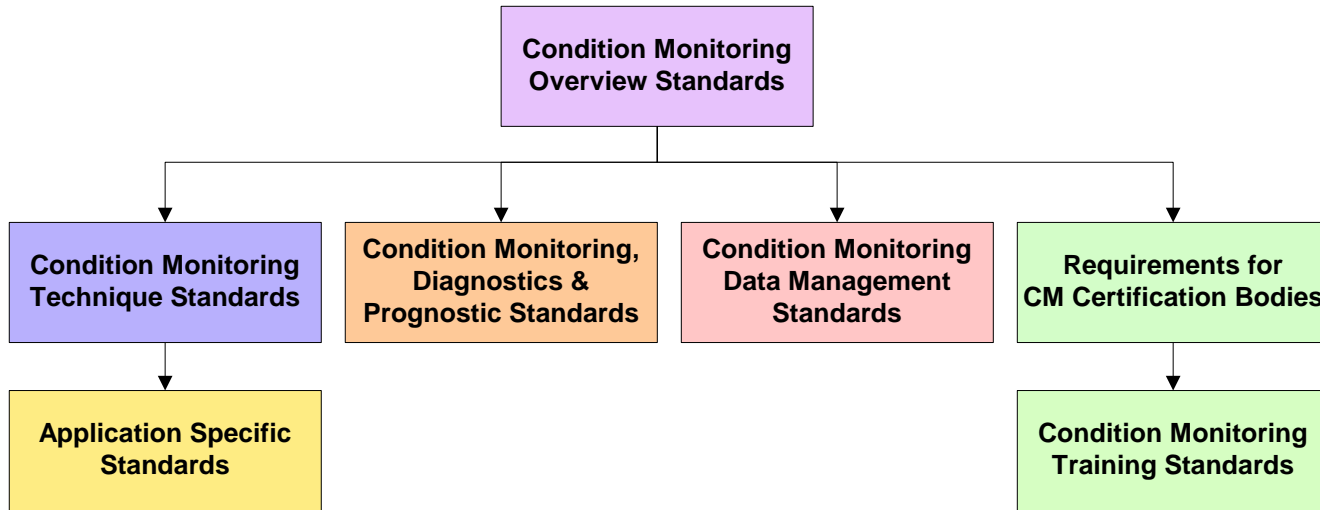
## ▶▶ ISO/TC 108/SC 5 – Condition Monitoring

- Development of technology of vibration CM, & other techniques such as thermal imaging & tribology led to the establishment of a new sub-committee under TC108 in the 1990's
- ISO/TC 108/SC 5 – Condition monitoring & diagnostics of machines



# ►► ISO Condition Monitoring Standards

- ISO/TC 108/SC 5 has issued **25** International Standards relating to Condition Monitoring and Diagnostics since 2000. Currently **4** are in development or review
  - ISO CM standards subject areas include:



# ▶▶ ISO 17359:2018 CM Guidelines

- ISO 17359:2018, Condition monitoring and diagnostics of machines – General guidelines
  - The umbrella document to ISO Standards covering Condition Monitoring (CM)
  - Originally issued in 2003
  - Second edition issued in 2011
    - Incorporated & superseded ISO 13380
  - Third edition published in 2018
    - Updates portfolio of CM Standards
    - Adds power transformer symptom table
    - Links from ISO 55000 Series



# ▶▶ ISO CM Standards (1 of 4)

- Overview
  - Vocabulary
- Data Management
  - Communications
  - Presentation
- CM Diagnostics
  - Diagnostics
  - Prognostics

## CM Overview

ISO 17359  
Condition monitoring & diagnostics  
of machines - General guidelines  
(TC108/SC5)

ISO 13372  
Condition monitoring & diagnostics  
of machines - Vocabulary  
(TC108/SC5)

ISO 2041  
Mechanical vibration, shock &  
condition monitoring - Vocabulary  
(TC108)

## CM Data Management

ISO 13374-1  
CM & diag. of m/c - Data proc.  
comm. & presentation Pt 1: General  
guidelines (TC108/SC5)

ISO 13374-2  
CM & diag. of m/c - Data proc.  
comm. & presentation  
Pt 2: Data processing (TC108/SC5)

ISO 13374-3  
CM & diag. of m/c - Data proc.  
comm. & presentation  
Pt 3: Communication (TC108/SC5)

ISO 13374-4  
CM & diag. of m/c - Data proc.  
comm. & presentation  
Pt 4: Presentation (TC108/SC5)

## CM Diag & Prognostics

ISO 13381-1  
CM & diag. of m/c - Prognostics -  
Part 1: General guidelines  
(TC108/SC5)

ISO 13379-1  
CM & diag. of m/c - Data interp. &  
diag. tech. - Pt 1: General guidelines  
(TC108/SC5)

ISO 13379-2  
CM & diag. of m/c - Data interp. &  
diag. tech. - Pt 2: Data-driven app.  
(TC108/SC5)

ISO 18129  
CM and diag of machines -  
Approaches for perf. diagnosis  
(ISO TC108/SC5)

# ►► ISO CM Standards (2 of 4)

## ● Techniques include

- Vibration
- Thermography
- Acoustic Emission
- Ultrasound
- Lubricant Sampling, Analysis & Tribology



CM Techniques	
ISO 13373-1 CM & diag. of m/c - Vib CM - Part 1: General procedures (TC108/SC2)	ISO 13373-9 CM & diag. of m/c - Vib CM - Pt 9: Diag techniques for electric motors (TC108/SC2 & SC5)
ISO 13373-2 CM & diag. of m/c - Vib CM - Part 2: Processing, analysis and pres. of vib data (TC108/SC2)	ISO/FDIS 14830-1 CM & diag of m/c sys - Tribology based monitoring & diag. Pt 1: General guidelines (TC108/SC5)
ISO 13373-3 CM & diag. of m/c - Vib CM - Pt 3: Guidelines for vib diag (TC108/SC2 & SC5)	ISO 18434-1 CM & diag. of m/c - Thermography - Part 1: General Procedures (TC108/SC5)
ISO/CD 13373-4 CM & diag. of m/c - Vib CM - Pt 4: Diag. tech. for gas & steam turb with fluid-film brgs (TC108/SC2 & SC5)	ISO 18434-2 CM & diag. of m/c - Thermography - Part 2: Image interpretation & diag (TC108/SC5)
ISO/DIS 13373-5 CM & diag. of m/c - Vib CM - Pt 5: Diag. tech. for fans and blowers (TC108/SC2 & SC5)	ISO 22096 Condition monitoring and diagnostics of machines - Acoustic emission (TC108/SC5)
ISO 13373-7 CM & diag. of m/c - Vib CM - Pt 7: Diag tech for m/c sets in hyd power gen & pump-storage plants (TC108/SC2 & SC5)	ISO 29821 CM & diag. of m/c - Ultrasound - General guidelines, procedures and validation (TC108/SC5)

# ►► ISO CM Standards (3 of 4)

## ● CM Applications

- Wind Turbines
- Structures
- Power Transformers
- Induction Motors
- Gas Turbines
- Hydro-electric Gen. Units

### CM Applications

#### ISO 16079-1

CM & diag of wind turbines - Pt 1:  
General guidelines (TC108/SC5)

#### ISO/DIS 19283

Condition monitoring & diagnostics  
of hydro-electric generating units  
(TC108/SC5)

#### ISO/DIS 16079-2

CM & diag of wind turbines - Pt 2:  
Detection of mech. faults of the drive  
train (TC108/SC5)

#### ISO 19860

Gas turbine trend monitoring  
(TC192)

#### ISO 16587

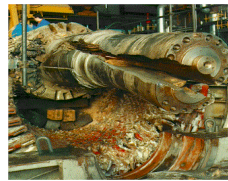
Mech. vib. & shock - Performance  
parameters for CM of structures  
(TC108)

#### ISO 20958-1

CM & diag. of m/c sys. - Electric  
signature analysis - Part 1: Three-  
phase induction motors (TC108/SC5)

#### ISO 18095

Condition monitoring and  
diagnostics of power transformers  
(TC108/SC5)





# ►► ISO CM Standards (4 of 4)

- Training Standards have also been developed
- ISO 18436 Series
  - Vibration
  - Thermography
  - Acoustic Emission
  - Lubricant Analysis
  - Ultrasound



## CM Training

### ISO 18436-2

CM & diag of m/c - Req for qual & ass. of pers. Pt 2: Vib CM & diag (TC108/SC5)

### ISO 18436-4

CM & diag. of m/c - Req for qual & ass. of pers. Pt 4: Field lubricant analysis (TC108/SC5)

### ISO 18436-5

CM & diag. of m/c - Req for qual & ass. of pers. - Part 5: Lubricant lab. technician/analyst (TC108/SC5)

### ISO 18436-6

CM & diag. of m/c - Req for qual. & assessment of personnel - Part 6: Acoustic emission (TC108/SC5)

### ISO 18436-7

CM & diag. of m/c - Req for qual & assessment of personnel - Part 7: Thermography (TC108/SC5)

### ISO 18436-8

CM & diag. of m/c - Req for qual & assessment of personnel - Part 8: Ultrasound (TC108/SC5)

## ►► **Recently Issued CM Standards**

- Recently published or revised ISO/TC 108/SC 5 Standards include:
  - ISO 17359 was re-issued as a 3rd edition in 2018
  - ISO 18095 was published in 2018
  - ISO 18434-2 was issued in 2019
  - ISO 29821 was issued in 2018
    - and combined ISO 29821 Part 1 & 2 into one part

# ►► Compliance with ISO 18436

- There are many organisations worldwide which *claim* compliance with ISO
  - These are **not** all third-party schemes and may be second-party or even first party conformance
  - Definitions for these terms are included below:
- first-party conformity assessment activity
  - conformity assessment activity that is performed by the person or organization that provides the object
- second-party conformity assessment activity
  - conformity assessment activity that is performed by a person or organization that has a user interest in the object
- third-party conformity assessment activity
  - conformity assessment activity that is performed by a person or body that is independent of the person or organization that provides the object, and of user interests in that object
- certification process
  - all activities by which a certification body establishes that a person fulfils specified competence requirements, including application, evaluation, decision on certification, surveillance and recertification, use of certificates and logos/marks
- Ref: ISO/IEC 17000 & ISO/IEC 17024

# ▶▶ BINDT CM Certification Scheme

- In the UK, BINDT has a well-established *third-party* certification scheme and runs examinations for the various categories of CM practitioners
- BINDT manages certification in compliance with appropriate parts of ISO 18436 for CM personnel in the following areas:
  - Vibration Analysis
  - Infrared Thermography
  - Wear and Debris Analysis
  - Acoustic Emission
  - Ultrasound (In development)



**BINDT**  
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NON-DESTRUCTIVE TESTING



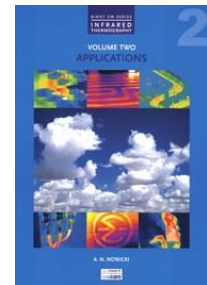
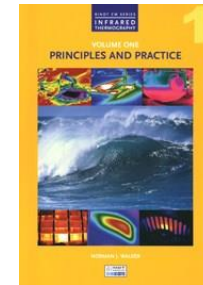
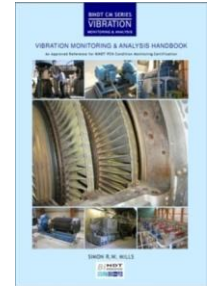
# ▶▶ BINDT CM Certification Scheme

- BINDT formally accredits Approved Training Organizations (ATO), and approves qualified trainers
- BINDT also manages the complete examination process
  - BINDT examinations are formally invigilated sessions using sealed papers
  - The BINDT scheme also requires successfully completion of a training examination before sitting a BINDT examination



# BINDT CM Series Handbooks

- BINDT is publishing a series of handbooks to support the CM certification schemes:
  - Vibration Monitoring and Analysis Handbook
    - To support the Vibration syllabus
    - Available from BINDT:
      - Price £90
  - Two Thermography Handbooks
    - To support the Thermography syllabus
    - Available from BINDT:
      - Price £65 each
  - An Introduction to CM and Diagnostic Technology handbook is in preparation
    - Will soon be available from BINDT:



# Vibration Analyst CM Syllabus

Ref	Subject	Cat 1	Cat 2	Cat 3	Cat 4
1	Principles of vibration	6	3	1	4
2	Data acquisition	6	4	2	2
3	Signal processing	2	4	4	8
4	Condition monitoring	2	4	3	1
5	Fault analysis	4	5	6	6
6	Corrective action	2	4	6	16
7	Equipment knowledge	6	4	4	-
8	Acceptance testing	2	2	2	-
9	Equipment testing and diagnostics	-	2	4	4
10	Reference standards	-	2	2	2
11	Reporting and documentation	-	2	2	4
12	Fault severity determination	-	2	2	3
13	Rotor and bearing dynamics	-	-	-	14
	<b>Total hours for each category</b>	<b>30</b>	<b>38</b>	<b>38</b>	<b>64</b>

# Thermography CM Syllabus

Ref	Subject	Cat 1	Cat 2	Cat 3
1	Introduction	0.5	-	-
2	Principles of infrared thermography (IRT)	6	7	6
3	Equipment and data acquisition	5	3	1
4	Image processing	6	2	1
5	General applications	4.5	-	-
6	Diagnostics & prognostics	1	2	2
7	Condition monitoring applications	4	10.5	7
8	Corrective actions	-	3	6
9	Reporting and documentation (ISO International Standards)	1	0.5	0.5
10	Condition monitoring program design	0.5	0.5	3.5
11	Condition monitoring program implementation	1	1	1
12	Condition monitoring program management	0.5	0.5	2
13	Training examination	2.0	2.0	2.0
	<b>Total hours for each category</b>	<b>32</b>	<b>32</b>	<b>32</b>



# ►► Conclusions

- The portfolio of International Standards encompassing Vibration and Condition Monitoring is still growing
  - Qualification and assessment in the field of CM is progressing well, and has gained an international credibility
- The certification scheme managed in the UK by BINDT ensures that certified CM practitioners utilise standard references, techniques and procedures whether they are specifying limits at the design stage, carrying out installation and acceptance testing, or routine monitoring
- These qualification and certification initiatives have an international market, and are contributing to standardising condition monitoring and diagnostics processes and procedures
  - They are having a positive impact throughout the asset management life cycle



## ▶▶ Questions

- Thank you for your attention
  - You are welcome to contact me if you have questions about BSI or ISO standardisation

# ►► References

- International Organization for Standardization (ISO) – [www.iso.org](http://www.iso.org)
- British Institute of Non-destructive Testing (BINDT) – [www.bindt.org](http://www.bindt.org)
- British Standards Institute – [www.bsigroup.com](http://www.bsigroup.com)
- ISO 17359:2018, Condition monitoring and diagnostics of machines – General guidelines
- ISO 18436-2:2014, Condition monitoring and diagnostics of machines – Requirements for qualification and assessment of personnel – Part 2: Vibration condition monitoring
- BINDT INST338, Infrared Thermography Handbook – Volume 1. Principles and Practice – N Walker – BINDT, ISBN 0 903 132 338
- BINDT INST32X, Infrared Thermography Handbook – Volume 2. Applications – A N Nowicki – BINDT, ISBN 0 903 132 32X
- BINDT INST397, Vibration Monitoring & Analysis Handbook – S R W Mills – BINDT, ISBN 978 0 903132 39 7