VIBRATION STANDARDS

ISO Standards

❖ The relevant ISO Standards are the following

- ISO 10816 : Mechanical Vibration – Evaluation of machine vibration by measurements on non-rotating parts.
- ISO 10816-1 : General guideline
- ISO 10816-2: Large land based steam turbine generator sets in excess of 50MW
- ISO 10816-3 : Industrial machines with nominal power above 15KW and nominal speeds between 120r/min and 15000 r/min when measured in site.
- ISO 10816-4 : Gas turbine sets excluding aircraft derivatives.
- ISO 10816-5 : Machine sets in hydraulic power generating and pumping plants.
- ISO 10816-6 : Reciprocating machine above 100kW

ISO Standards

ISO 7919 : Mechanical vibration of non-reciprocating machines – Measurements on rotating shafts and evaluation criteria

- **ISO 7919-1** : General guidelines
- **ISO 7919-2** : Land based steam turbines and generators in excess of 50MW with norm al operating speeds of 1500 r/min , 1800 r/min , 3000 r/min and 3600 r/min.
- **ISO 7919-3** : Coupled industrial machines
- **ISO 7919-4** : Gas turbine sets
- **ISO 7919-5** : Machine sets in hydraulic power generating and pumping plants.

ISO Standards

ISO 2954 : Mechanical vibration of non-reciprocating machines – requirements for instruments for measuring vibration severity.

ISO 8579-1 :Acceptance code for gear units –Part 1 : Test code for airborne sound.

ISO 8579-2 :Acceptance code for gear units –Part 2 : Determination of mechanical vibrations of gear units during acceptance testing.

API Standards

- The relevant API Standards are the following

- API STANDARD 610 : Centrifugal Pumps for petroleum, Heavy Duty Chemical and Gas Industry Services – 1994.
- API STANDARD 611 : General Purpose Steam Turbines for Petroleum, Chemical and Gas Industry Services.
- API STANDARD 612 : Special Purpose Steam Turbines for Petroleum, Chemical and Gas Industry Services – Jun 1995
- API STANDARD 613 : Special Purpose Gear Units for Petroleum, Chemical and Gas Industry Services – Jun 1995

API Standards

- The relevant API Standards are the following

- API STANDARD 616 : Gas Turbines for Petroleum, Chemical , and Gas Industry Services – Aug 1998.
- API STANDARD 617 : Centrifugal Compressors for Petroleum, Chemical and Gas Industry Services – Feb 1995.
- API STANDARD 618 : Reciprocating Compressors for Petroleum , Chemical and Gas Service Industry Services – 1995.

API Standards

❖ The relevant API Standards are the following

- API STANDARD 670: Machinery Protection Systems – Dec 2000
- API STANDARD 671 : Special Purpose Coupling for Petroleum , Chemical and Gas Industry Service – Oct 1998
- API STANDARD 672 : Packaged, Integrity Geared Centrifugal Plant and Instrument Air Compressors for General Refinery Service.
- API STANDARD 673 : Special Purpose Centrifugal Fans for General Refinery Service – Jan 1982

API Standards

❖ The relevant API Standards are the following

- API STANDARD 674: Positive Displacement Pumps - Reciprocating
- API STANDARD 675 : Positive Displacement Pumps – Controlled volume.
- API STANDARD 676 : Positive Displacement Pumps - Rotary
- API STANDARD 677 : General Purpose Gear Units for General Refinery Service
- API STANDARD 678 : Accelerometer Based Vibration Monitoring System.

API Standards

- The relevant API Standards are the following

- API STANDARD 684: Tutorial on the API Standard Paragraphs Covering Rotor Dynamics and Balancing:

  An Introduction to Literal Critical and Train Torsional Analysis and Rotor Balancing.

ISO STANDARD 10816

ISO Standards 10816

❖ The standard evolution

The international standard ISO 10816 (1995) replace the former standard ISO 2372 (1974)

Then main modifications are related to the following points:

- Evaluation of the vibration severity according to 2 criterions
  - * Vibration magnitude
  - * Change in the vibration magnitude
- The use of the other units and parameters is now possible
  - * Broad band in acceleration for displacement
  - * Narrow band in acceleration, velocity or displacement.

ISO Standards 10816

- The Standards evolutions.

The evolution aims to allow:

- A better standard relevance for the machines running at slow or high speed (< 600 r/min or > 12000 r/min)
- Taking into account the measurement tools improvements and in particular the generalization of the use of the frequency analyzers.
- Taking into account the specificities of the various categories of machines according to their type , their installation status, and their operation parameters.

ISO Standards 10816

❖ ISO 10816 : Mechanical Vibration – Evaluation of machine vibration by measurements on non-rotating parts

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- ISO 10816-3 : Industrial machines with nominal power above 15KW and nominal speeds between 120r/min and 15000 r/min when measured in site.
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ISO Standards 10816

❖ Monitoring principle

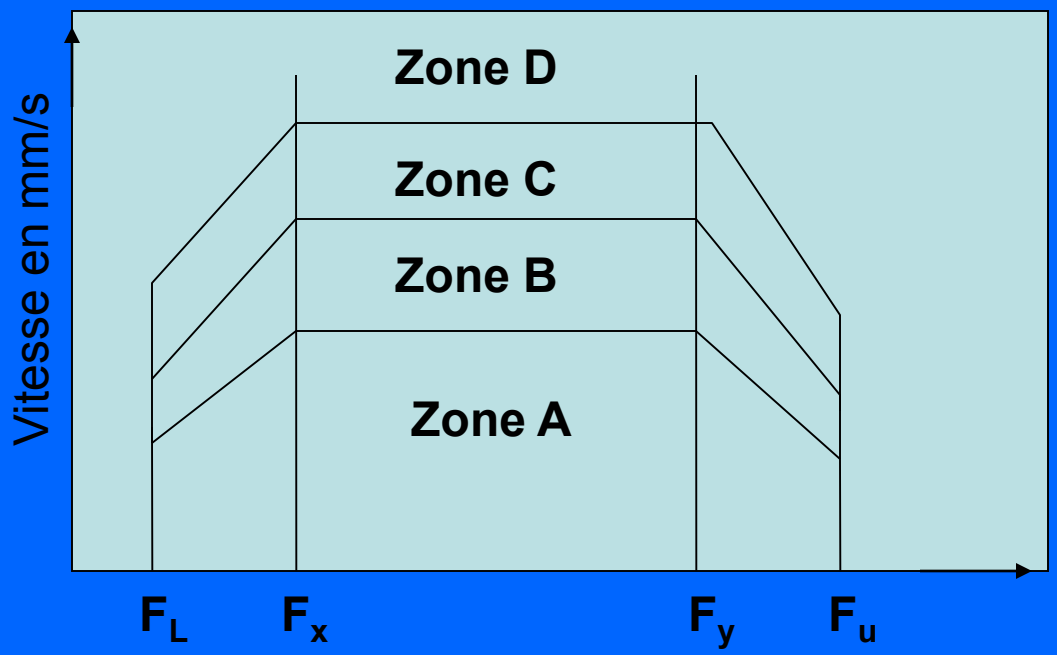
The evaluation of the vibrations is based on the following principles:

- Measurements of the velocity using broad band analysis
- Comparison to acceptance criteria depending on the machine's class, type and power : Criteria 1
- Comparison to the changes in the vibration magnitude to acceptance criteria : Criteria 2

ISO Standards 10816

❖ **Velocity acceptance criteria : general shape**

$$Vrms = V_A.G\ (F_z / F_x)^k.\ (F_y/F_w)^m$$



VRMS : allowable RMS velocity, in mm/s

VA : Constant RMS velocity, in mm/s , which applies between fx and fy for zone A

G: factor which defines the zone boundaries

Example:

- G=1 For Zone A
- G=2.56 for Zone B
- G=6.4 for Zone C
- K et m : constants for given machine type.

ISO Standards 10816

- Evaluation zone limits

- **Zone A** : The vibration of newly commissioned machine would normally fall within this zone.
- **Zone B** : Machine with vibration within this zone are normally considered acceptable for restricted long term operation.
- **Zone C** : machines with vibration within this zone are normally considered unsatisfactory for long-term continuous operation. Generally the machine may be operated for a limited period in this condition until suitable opportunity arises for remedial action.
- **Zone D** : Vibration values within this zone are normally considered to be of sufficient severity to cause damage to the machine

ISO Standards 10816

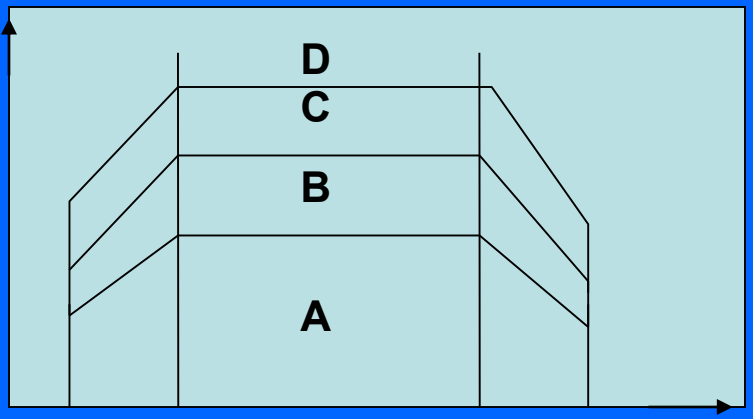
❖ ISO 10816-2 : Large land based steam turbine generator sets in excess of 50MW

- RMS velocity value Vrms during nominal and steady running conditions.
- Broad band measurements (10-A) Hz – A -> 500 Hz.
- The zone limits are given according to the machine rotational speed.
  - 1500/ 1800 r/min
  - 3000/3600 r/min

ISO Standards 10816

- ISO 10816-2 : Large land based steam turbine generator sets in excess of 50MW

Zone limits	Vrms (mm/s)	
	1500/1800 r/min	3000/3600 r/min
A/B	2.8	3.8
B/C	5.3	7.5
C/D	8.5	11.8



ISO Standards 10816

❖ **ISO 10816-3** : Industrial machines with nominal power above 15kW and nominal speeds between 120 r/min and 15000 r/min when measured in situ.

- RMS velocity value V_{rms} and RMS displacement D_{RMS} during nominal and steady running conditions.
- Broad band measurements (10-1000) Hz,
  If speed >600 RPM.
- Broad band measurements (2-1000) Hz ,
  If 120 < speed < 600 RPM.
- The zone limits are given according the machine group and mounting type.

ISO Standards 10816

❖ **ISO 10816-3** : Industrial machines with nominal power above 15kW and nominal speeds between 120 r/min and 15000 r/min when measured in situ.

- **Group 1** : Large machine with rated power above 300KW and not more than 50MW; electrical machine with shaft height H>315 mm

Support Class	Zone Boundary	D_{RMS} (μM)	V_{RMS} (μμ/σ)
Rigid	A/B	29	2.3
Rigid	B/C	57	4.5
Rigid	C/D	90	7.1
Flexible	A/B	45	3.5
Flexible	B/C	90	7.1
Flexible	C/D	140	11.0

ISO Standards 10816

❖ **ISO 10816-3** : Industrial machines with nominal power above 15kW and nominal speeds between 120 r/min and 15000 r/min when measured in situ.

- **Group 2** : Medium size machine with rated power above 15 KW up to including 300kW ; electrical machine with shaft height 160 mm < H < 315 mm

Support Class	Zone Boundary	D_{RMS} (μM)	V_{RMS} (μμ/σ)
Rigid	A/B	22	1.4
Rigid	B/C	45	2.8
Rigid	C/D	71	4.5
Flexible	A/B	37	2.3
Flexible	B/C	71	4.5
Flexible	C/D	113	7.1

ISO Standards 10816

- **ISO 10816-3** : Industrial machines with nominal power above 15kW and nominal speeds between 120 r/min and 15000 r/min when measured in situ.

  - **Group 3** : Pumps with multivane impeller and separate driver (centrifugal, mixed , flow or axial flow) with rated power above 15kW

Support Class	Zone Boundary	D_{RMS} (μM)	V_{RMS} (μμ/σ)
Rigid	A/B	16	2.3
Rigid	B/C	36	4.5
Rigid	C/D	56	7.1
Flexible	A/B	26	3.5
Flexible	B/C	56	7.1
Flexible	C/D	90	11.0

ISO Standards 10816

❖ **ISO 10816-3** : Industrial machines with nominal power above 15kW and nominal speeds between 120 r/min and 15000 r/min when measured in situ.

- **Group 4** : Pump with multi vane impeller integrated driver (centrifugal, mixed flow or axial flow) with related power above 15kW

Support Class	Zone Boundary	D_{RMS} (μM)	V_{RMS} (μμ/σ)
Rigid	A/B	11	1.4
Rigid	B/C	22	2.8
Rigid	C/D	36	4.5
Flexible	A/B	18	2.3
Flexible	B/C	36	4.5
Flexible	C/D	55	7.1

ISO Standards 10816

❖ **ISO 10816-4** : Gas turbine sets excluding aircraft derivates

- RMS velocity value V_{RMS} during nominal and steady running conditions.
- Broad band measurements (10-B) Hz – B >6 x Fo
  Fo : shaft rotational frequency (Hz)
- The shaft rotational speed must between 300 r/min and 20000 r/min.

ISO Standards 10816

❖ **ISO 10816-4** : Gas turbine sets excluding aircraft derivates

Zone Boundary	V_{RMS} (mm/s)
A/B	4.5
B/C	9.3
C/D	14.7
Note: This value can be use for measurements in radial direction on the shaft bearings and axial direction on the thrust bearings.	

ISO Standards 10816

- **Criterion 2: ALARM value**

  - The criterion 2 is based on the changes in vibration magnitude from previously established reference value (baseline)
  - It is the recommended that the ALARM value should be set higher than the baseline by an amount equal to 25% of the upper limit for zone B. If the baseline is low, the ALARM may be below zone C.
  - It is recommended that the ALARM value should not normally exceed 1.25 times the upper limit for the zone B.

ISO Standards 10816

- **Criterion 2: TRIP value**

  - The criterion 2 is based on the changes in vibration magnitude from previously established reference value (baseline)

  - It is the recommended that the ALARM value should not normally exceed 1.25 times the upper limit for zone B

ISO Standards 10816

- **Interim broad band vibration criteria for specific machine groups**

  - It is intended that evaluation criteria for specific machine types will be provided in additional parts of ISO 10816 9 so far: part 2 to 6). However, as a short-term expedient only, limited evaluation criteria are provided (from the former ISO 2372) until the relevant parts become available.

ISO Standards 10816

- **Interim broad band vibration criteria for specific machine groups : Machine classification**

  - **Class I** : Individual parts of engines and machines, Integrally connected to the complete machine in its normal operating condition. (production electrical motors of up to 15kW are typical examples of machines in this category).

  - **Class II** : Medium size machines (typically electrical motors with 15kW to 75kW output) without special foundations, rigid mounted engines or machines (up to 300kW) on special foundation.

ISO Standards 10816

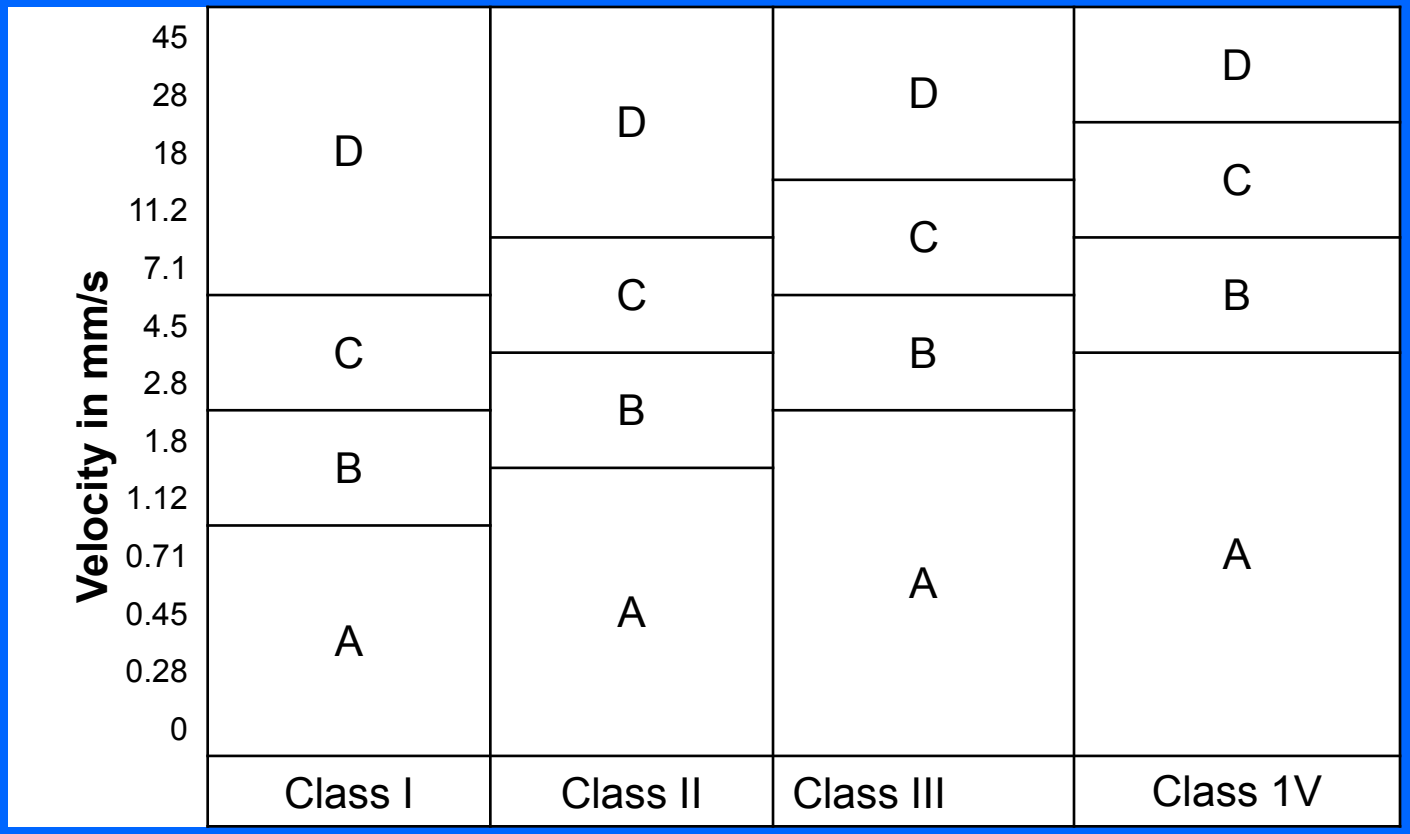
- **Interim broad band vibration criteria for specific machine groups : Machine classification**

  - **Class III** : Large prime-movers and other large machines with rotating masses mounted on rigid and heavy foundation which are relatively stiff in the direction of vibration measurements.

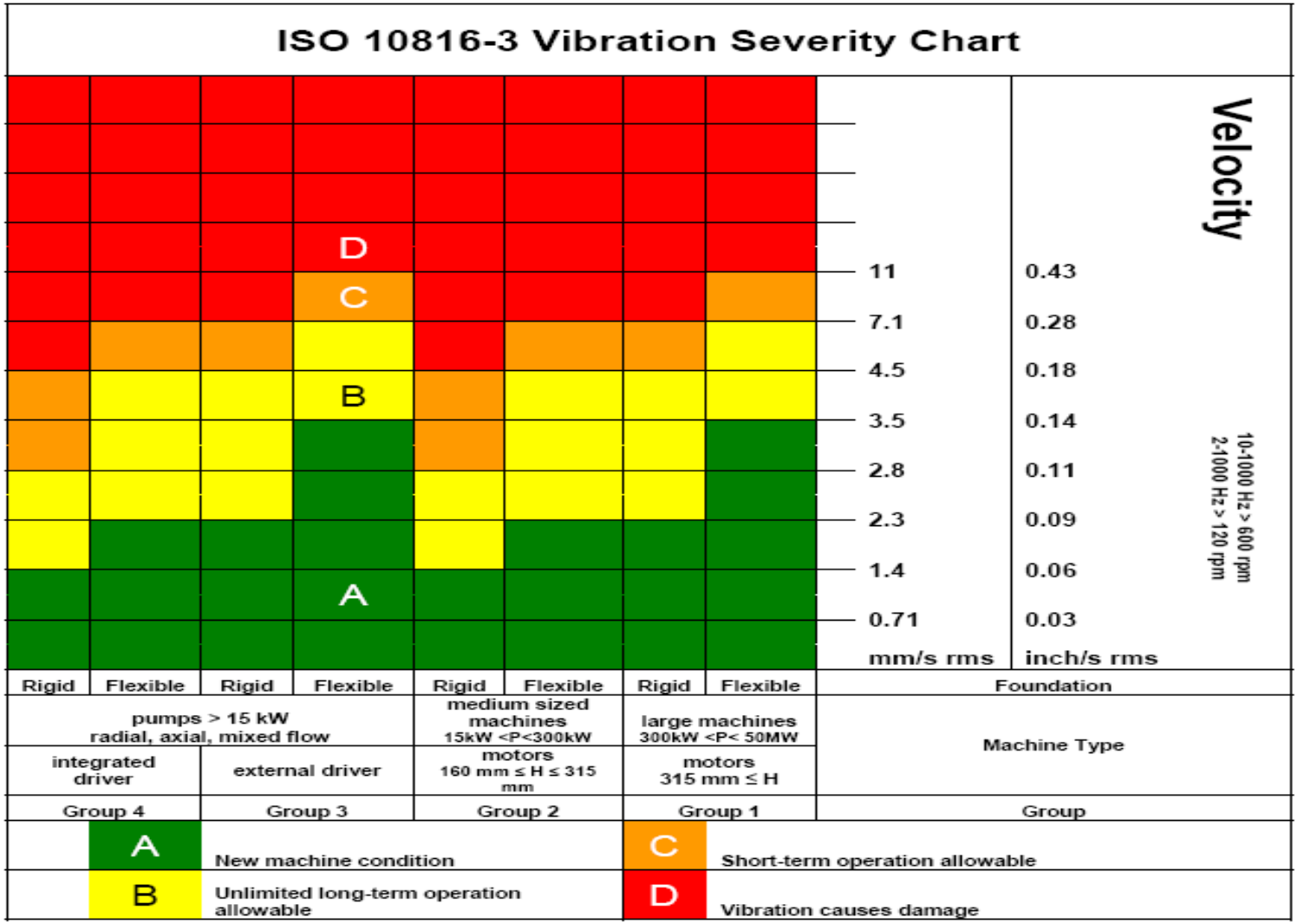
  - **Class IV** : Large prime-movers and other large machines with rotating masses mounted n foundation which are relatively soft in the direction of vibration measurements (for example turbo generator sets and gas turbines with outputs greater than 10MW)

ISO Standards 10816

- **Interim broad band vibration criteria for specific machine groups : Machine classification**



ISO Standards 10816



Conclusion

- Provides a common reference for everybody (end user , manufacturer , consultant)

- Allows monitoring defects between 2 and 100Hz
  - * Mass unbalance, misalignment, looseness , etc.
  - * These phenomenon represent most of the problems while commissioning.

- Does not allow to monitor all the possible mechanical defects (above 1000Hz)
  - * Ball bearing general wear, belt bearing flaws, gear mesh, hydraulic defect, lubrication, etc.
  - * Additional parameter must be used to have a “state of art” monitoring.