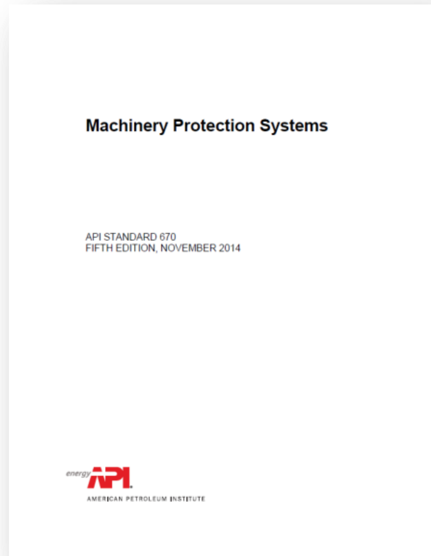
Comments

API 670 5th Edition – Machinery Protection Systems

Overview

This document summarizes comments regarding the SETPOINT™ Machinery Protection and Condition Monitoring System compliance to American Petroleum Institute Standard 670 – 5th Edition (Nov 2014). For ease of reference, our comments are organized by the paragraph numbers used in API 670. However, the API 670 standard itself is not contained in this document and must be purchased from API. Refer to the API 670 Publication Announcement, attached as pages 15-20 of this document. It contains ordering information, pricing*, page count, publication number, an overview, and a table of contents for the standard.


Machinery Protection Systems

API STANDARD 670
FIFTH EDITION, NOVEMBER 2014

AMERICAN PETROLEUM INSTITUTE

API 670 5th edition consists of both normative and informative content. Normative content is used to specify requirements. Informative content is tutorial or educational in nature and is not intended to specify requirements. Sections 1 through 12 of the standard are all normative. The 17 annexes also included in the standard reflect a mix of normative and informative content as summarized in Table 1. Users of the standard will find these distinctions particularly important, as informative content was not written in a manner that allows it to be easily adapted as requirements.

API standards use a bullet (•) to denote any paragraph where a decision is required among multiple options or further information is to be provided by the purchaser. Annex A provides datasheets* that allow the purchaser to summarize all of this information and option selections.

Some users of the standard develop company-specific “overlay” documents that augment or relax certain requirements, clarify “if-specified” preferences, and provide additional guidance to the supplier.

*NOTE: Hardcopy and electronic (PDF) copies of the standard contain blank copies of datasheets as Annex A, but they are not interactive. Interactive versions of datasheets (Microsoft Excel® format) are available separately as API publication C6700D for $59.00 USD. See ordering information by going to www.api.org/pubs and searching on “670.”

Table 1 – Normative and Informative Annex Summary

Annex	Title	Pages	Normative	Informative
A	Machinery Protection System Datasheets*	9		•
B	Typical Responsibility Matrix Worksheet	1		•
C	Accelerometer Application Considerations	5	•	
D	Signal Cable	3	•	
E	Gearbox Casing Vibration Considerations	2	•	
F	Field Testing & Documentation Requirements	3	•	
G	Contract Drawing & Data Requirments	5		•
H	Typical System Arrangement Plans	7		•
I	Setpoint Multiplier Considerations	4		•
J	Electronic Overspeed Detection System Considerations	4	•	
K	Surge Detection and Antisurge Control	4		•
L	Safety Integrity Level	20		•
M	Considerations Regarding Spurious Shutdowns and Use of Functional Safety Methodology to Reduce Economic Losses	4		•
N	Condition Monitoring	50		•
O	Overspeed	7	•	
P	Reciprocating Compressor Monitoring	10		•
Q	Considerations when Using Wireless Connectivity Technologies	8		•

History of API 670

First Edition: June, 1976

Initial development of API 670 was driven by the need for machinery users to specify proximity probes and monitoring systems pre-installed on their machinery packages that would conform to basic functional, performance, and interchangeability requirements. This helped ensure that sensors from one manufacturer would work with monitoring systems from another manufacturer. It also assured that transducer system cable lengths, probe configurations, tip diameters, and oscillator/demodulators had a limited number of permutations to help reduce spare parts requirements. First Edition covered only radial vibration and axial position (thrust) measurements. It did not cover seismic (casing) vibration, bearing temperature, or any of the other measurements introduced in later editions of the standard.

Second Edition: June, 1986

Second Edition introduced content pertaining to bearing temperature measurements.

Third Edition: November, 1993

A separate standard (API 678) was released in May, 1981 and covered accelerometer-based vibration monitoring systems. Thus, for a period of time, two separate API standards coexisted – one for proximity probe-based systems and another for accelerometer-based (seismic) systems. The two standards had considerable overlap and represented redundant efforts to maintain. The primary goal of the Third Edition task force was thus merging both standards into a single document. Consequently, API 678 was withdrawn from use with the publication of 670 Third Edition. Third Edition also introduced new appendices covering vendor drawing and documentation requirements, field testing and documentation requirements, accelerometer application considerations, and gearbox casing vibration considerations.

Fourth Edition: December, 2000

Fourth Edition focused on content that had become dated and assumed analog rather than newer digital technology (such as indicators that may no longer be physical lamps or LEDs). It introduced if-specified options to segregate the machinery protection system into smaller functional subcomponents that could be physically separate from one another (such as a non-integral display), but retained a “contiguous system” as the default. It also introduced the inclusion of overspeed detection instrumentation and piston rod drop measurements. Sensors were expanded to include magnetic pickups for speed measurements, and appendices were added for setpoint multiplier considerations and electronic overspeed detection systems. The types of measurements covered by the standard had become long enough that it was tedious to list them all as part of the title. The standard was thus renamed “Machinery Protection Systems” instead.

Fifth Edition: November, 2014

Fifth Edition represents a significant revision to the standard and organizes the protection system into subsystems as follows:

- Vibration/Position/Temperature/Rod Drop Systems (section 7)
- Overspeed Detection Systems (section 8)
- Surge Detection Systems (section 9)
- Emergency Shutdown Systems (section 10)
- Final Shutdown Elements (10.8)
- Other Inputs (10.7.2)

Some sections (1-6, 11, 12) now pertain to all of these subsystems, while other sections (7-10) only pertain to selected subsystems as noted above.

Surge Detection and Emergency Shutdown Systems are entirely new as are Annexes K-Q. Annex N alone adds a 50-page tutorial on condition monitoring; Annex L adds a 20-page tutorial on Safety Integrity Level (SIL); and, Annex P adds a 10-page tutorial on reciprocating compressor monitoring. Page counts of other new Annexes are as summarized in Table 1 on the prior page. In addition, normative content pertaining to overspeed is substantially expanded. As a result, the page count of the standard has grown from 96 pages in Fourth Edition to 244 pages in Fifth Edition. Also, the use of color is now present in illustrations. Prior editions of the standard were limited to black and white line art.

Comments

The SETPOINT system is fully compliant with API 670 5th edition. Comments herein provide relevant explanatory or tutorial information regarding how we comply. They also describe certain "if specified" options in the standard and their availability in the SETPOINT platform.

Products evaluated for compliance here are as follows:

- ***SETPOINT Machinery Protection System***
- ***SETPOINT Condition Monitoring System***

For API 670 compliance of proximity sensors, accelerometers, and velocity sensors, see Metrix document 1365856. For API 670 compliance of surge detection, overspeed, and emergency shutdown systems, refer to the appropriate supplier, such as Compressor Controls Corporation.

4.9.3 RFI Immunity

Comment The SETPOINT system utilizes an all-metal chassis that provides outstanding immunity to RFI and very low radiated emissions. The use of separate metal enclosures, armored cables, and metallic conduit is not required to achieve CE Mark or EN 61000-6-2 compliance.

4.9.4 Conformal Coating

Comment All circuit boards are conformal coated except those used on the System Access Module (SAM) as the microprocessor sockets used in the SAM do not permit conformal coating. The SAM is not part of the critical path in machinery protective functions; it facilitates communications and display functions only.

4.10 Power Supplies

Comment The SETPOINT system is energized by external 24 Vdc power. Power supplies to convert from AC voltages (or higher DC voltages) to 24 Vdc are located outside of the SETPOINT rack. This design philosophy minimizes heat sources within the rack enclosure, extending component life. The SETPOINT Rack Connection Module (RCM) accepts power from two independent sources. It is not a power supply, but is merely a distribution mechanism to route power from simplex or redundant external power sources to the rack's backplane. RCM redundancy is achieved by the use of a Power Connection Module, a special type of RCM that can reside in any slot in the rack. It duplicates the power distribution capabilities of the RCM in rack slot 1. The design philosophy of the SETPOINT system does not use centrally regulated voltages for microprocessors, transducers, and other system excitation requirements. Instead, each module in the rack uses the 24 Vdc power distributed along the backplane to regulate and generate necessary voltages needed for operation. This approach assures that failure of a voltage regulation circuit affects only a single module – not the entire rack.

4.10.2.a 19 Vdc to 32 Vdc Power Supply Option

Comment The SETPOINT system is energized by external 24 Vdc (nominal) power. An external supply is not required for voltages between 22 Vdc and 30 Vdc, with transients between 18 Vdc and 36 Vdc.

4.10.6 Power Supply Noise Immunity

Comment The SETPOINT system is fully CE compliant and marked.

4.10.9 Transformer Windings

Comment All supplies are fully independent.

4.10.10 Redundant Power Supplies

Comment Complete power supply and power distribution redundancy is available. See also comments to 4.10.

4.11.1 and 4.11.2 Reliability Documentation

Comment MTTR, TI, MTBF, PFD, and other data to allow determination of the safety integrity level (SIL) is available upon request.

4.11.3.a Indicator Test

Comment Power-up tests all LED indicators on modules; touchscreen display is always on and uses different colors to annunciate status conditions.

4.11.4.a Channel Isolation

Comment The SETPOINT system incorporates independent supplies and input circuits for each channel.

4.11.4.b OK Checks and Indicators

Comment Internal self tests and transducer OK checks are fully implemented. A no-fault condition is indicated by means of green LEDs on modules and green backgrounds on touchscreen display.

4.11.4.d Front Panel Buffered Output Connectors

Comment The SETPOINT system uses an RJ-45 connector on each monitor module (except temperature) instead of BNC connectors. This design facilitates easier multi-channel cable runs over long distances by using CAT5 cable carrying four channels instead of individual coaxial cables carrying only one channel. A special cable adapter (p/n 100431) is provided that breaks out the signals at each RJ45 connector into four individual BNC connectors. Buffered outputs from all 56 vibration channels in a rack are also available at a special 30-pin connector pair on the Rack Connection Module (RCM).

4.11.4.e 4-20mA Outputs

Comment 4-20mA outputs are standard on all channels. They are individually programmable for any measurement from any channel*.

* **NOTE:** A channel on one module cannot drive a 4-20mA output on a separate module.

4.11.4.f CMS Interface

Comment This interface is available via the DAQ connector on each enhanced System Access Module (eSAM). The protocol is open and documentation detailing this protocol is available upon request. It is directly compatible with the OSIsoft PI System when running the SETPOINT-to-PI Adapter service.

4.11.5.d Alarm Response Time

Comment The alarm *response* time should not be confused with the alarm *delay* time. The alarm response time is not programmable. The alarm delay time is programmable (see 7.1.5.1). The alarm response time is the maximum time that can elapse in the system before detecting that a channel's value has violated a setpoint. Once a setpoint violation occurs, the violation must be *sustained* for the alarm delay time before an alarm will be annunciated. This means that setpoint violations shorter than the alarm delay time will be detected, but not annunciated. SETPOINT fully complies with all requirements for alarm response times and programmable alarm delay times.

4.12.3 Epoxy-Sealed Relays

Comment Four (4) epoxy-sealed, fully-programmable electro-mechanical relays are standard and self-contained on each vibration or temperature monitoring module. Up to 14 monitor modules can reside in a rack, in any mix. Separate relay modules are not required, maximizing the number of monitoring channels that can fit within a rack.

4.12.4 Hermetic or Solid-State Relays

Comment Epoxy-sealed, fully-programmable electro-mechanical relays are standard. Options for hermetically sealed or solid-state relays are not available at this time. The original intent for mandating hermetically sealed relays was based on their reliability and increased protection from contaminants compared to *non-sealed* relays. Thus, hermetically sealed relays were required in 1st, 2nd, and 3rd editions of the standard. However, in 4th edition, epoxy-sealed relays became the default. The key word here is *sealed*. When relays are properly sealed, they provide the required reliability. Epoxy-sealed relays thus became standard and hermetically-sealed relay were relegated to an "if-specified" option due to their larger size and larger power consumption requirements without correspondingly higher reliability. Solid-state relays are discouraged due to extensive application-related constraints such as holding currents, leakage currents, and other issues not present in electro-mechanical relays. This is why 4.12.4.b includes the words "…complete review of the relay capabilities and requirements to ensure reliable operation" regarding the use of solid-state relays.

4.12.11.c System Shutdown Disabled Annunciator

Comment When a rack inhibit condition is invoked by shorting the INH and COM terminals on the Rack Connection Module, this is annunciated on the touchscreen when in RACK view. Additionally, the red LED indicator for bypass (BYP) will illuminate on each module.

4.12.11.d Power Supply Replacement While Disarmed

Comment If UMM relay contacts (see comments to 4.12.11.f) are used for isolating the monitor system from the ESD while in shutdown bypass (disarmed) mode, they must be normally de-energized relays. This ensures they will not change state when power is removed from the rack.

4.12.11.f System Shutdown Disabled Annunciator Contacts

Comment The SETPOINT system can be configured such that two relay contacts on any available UMM will change state when the rack inhibit condition is invoked on the RCM. A keylock switch to invoke this condition can be provided upon request.

4.13.1 Digital Communication Link Protocols

Comment The SETPOINT System Access Module (SAM) provides both MODBUS TCP (Ethernet) and MODBUS RTU (serial) communications. Both interface share a common register map.

4.13.2 Digital Communication Link Data Types

Comment The following optional data types are not available via MODBUS at this time:

c) alarm list

e) channel value as a percent of alarm

g) transducer OK limits

i) communication link status

l) date/time stamp affixed to each data type

m) system event list

However, all of the above are available via an optional OPC interface, which is better suited for transmission of these data types than is MODBUS. They are also available via the system's touchscreen display and maintenance (configuration) software.

4.11.5.g Reset

Comment SETPOINT modules can be inserted from the front or rear of the rack chassis. A local RESET pushbutton is provided on the face of the Rack Connection Module (RCM) along with wiring terminals for invoking this function via a remote switch. The RESET command can also be invoked via the touchscreen display which may be on the opposite side of the rack from the wiring terminals.

4.11.5.h First-Out Indication

Comment A detailed alarm list with time/date stamp is standard, showing when any channel enters and leaves an alarm condition. The list can be sorted to allow easy identification of the channel that was first to enter an alarm condition.

5.1.5 Magnetic Speed Sensors

Comment Will be supplied from third party when required to meet project scope of supply and API compliance. Metrix strongly encourages speed measurements via proximity probes rather than magnetic speed sensors for the reasons detailed in Annex J and in 6.1.7.2 Note 3.

5.3 Temperature Sensors

Comment Will be supplied from third party when required to meet project scope of supply and API compliance.

7.1.2 Contiguous Enclosure

Comment A single SETPOINT rack accommodates up to fourteen 4-channel vibration monitors (56 channels) or fourteen 6-channel temperature monitors (84 channels). Vibration and temperature modules may be intermixed in the rack as a required. The rack is also capable of supporting a 15th module of either type, rather than a System Access Module (SAM), but the rack will then be unable to connect to a local or remote display, as required by this standard. Power supplies in the SETPOINT rack are external, not internal, per our comments to 4.10. We believe this design philosophy is a superior approach that affords customers more flexibility, lower spare parts costs, and reduces the heat trapped inside a rack enclosure that accelerates electronic component degradation over time.

7.1.3.a Affected Channels Under Single Failure

Comment SETPOINT racks utilize 4-channel vibration modules and 6-channel temperature modules. By properly segregating channels to appropriate modules during the configuration process, compliance with this paragraph is achieved.

7.1.3.b Display Resolution

Comment Display resolution for vibration and temperature is better than 1% of full scale. For speed channels, 1 rpm or 0.2% of full scale, whichever is greater.

7.1.3.c Controlled Access Protection

Comment A keylocked door excludes access to system configuration ports used to adjust these parameters.

7.1.3.d Phase Reference Transducers

Comment A 16-slot SETPOINT rack can accommodate six separate phase reference transducers. 8-slot racks can accommodate five separate phase reference transducers. 4-slot racks can accommodate only one phase reference transducer.

7.1.3.e CMS Interface

Comment See comments to 4.11.4.f.

7.1.4 Gain Adjustment

Comment User programmable via controlled access; default channel type is radial vibration with 7.87 mV/μm

(200 mV/mil) scale factor.

7.1.5.c Per-Channel Alarm Annunciators

Comment Alarm annunciation is provided for individual channels in axial position channel pairs. Logical alarm voting between the channels in a pair is programmable for single (7.4.2.4) or dual (7.4.2.5) voting.

7.3.2 Number of Relays

Comment Fully compliant. Each monitor module in the SETPOINT system has four (4) self-contained relays as standard. Separate relay modules are not required. These relays are fully programmable for any required voting logic and can be driven by any combination of channels/alarms. See also comments to 7.1.5.c and 4.12.3.

7.4 Monitor Systems

Comment The SETPOINT system uses two fundamental monitoring modules for all measurements: the 4-channel Universal Monitoring Module (UMM) and the 6-channel Temperature Monitoring Module (TMM). These modules are fully self-contained monitors, requiring only 24 Vdc power to operate, and with their own on-board relays and 4-20mA outputs. Channel types in UMMs are fully programmable for all* API 670 vibration, position, and speed measurements including radial vibration (7.4.1), axial position (7.4.2), speed (7.4.6), phase (6.1.5), rod drop (7.4.3.1), rod position (7.4.3.3), and casing vibration (7.4.4). Channel types in TMMs are fully programmable for all API 670 temperature measurements (7.4.5).

NOTE: Overspeed, surge detection, and ESD functionality are not supported in the SETPOINT system at this time. See comments to sections 8, 9, and 10.

7.4.4.5 Dual-Path Monitoring

Comment A SETPOINT UMM channel can be programmed to make any of the measurements discussed in 7.4.4.5. Dual-path measurements consume only a single channel in a UMM even though the velocity path is in rms and the acceleration path is in true peak. Filter corners are fully programmable for each path.

7.4.4.6 Optional Configurations for Casing Vibration Channels

Comment A SETPOINT UMM channel can be programmed to make any of the measurements discussed in 7.4.4.6. Full-scale ranges, amplitude detection method, integration, filter corners, and voting logic are fully programmable.

7.4.6 Speed Indicating Tachometer

Comment Basic tachometer functions are supported (speed, peak speed hold, rotor acceleration, zero speed, reverse rotation), but alarm delays on these measurements may not be set to less than 1 second to ensure they are not used for overspeed applications. See also comments to section 8.

7.4.6.3 Tachometer Sensor Types

Comment Speed inputs are supported from proximity probes and magnetic pickups; input type and number of events per revolution are fully programmable.

7.5.2 Outdoor Installations

Comment Weatherproof enclosures with viewing windows are available for the SETPOINT rack and any required external power supplies. An ultra-bright touchscreen display allows excellent visibility in both indoor and outdoor installations. An optional wireless mouse or trackball can be supplied to allow interaction with rack touchscreen without opening the housing.

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8 Electronic Overspeed Detection System

Comment Overspeed measurements are not supported in the SETPOINT system at this time. Basic tachometer functions are supported (speed, rotor acceleration, zero speed, reverse rotation), but alarm delays on these measurements may not be set to less than 1 second. Speed inputs for basic tachometer functions are supported from proximity probes and magnetic pickups.

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9 Surge Detection Systems

Comment Surge detection measurements are not supported in the SETPOINT system at this time.

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10 Emergency Shutdown Systems (ESDs)

Comment The SETPOINT system is designed to be an input to an ESD. Although it can drive final control elements directly in some cases, it is not a general-purpose logic solver. It is designed to function only as the vibration monitoring system of section 7.

10.4.3 Integrated System

Comment For both the distributed (10.4.2) and integrated (10.4.3) ESDs, the vibration monitoring system (denoted in blue in Figures 21 and 22) is always separate from the other systems. While the integrated ESD may encompass the surge and/or overspeed systems, it does not encompass the vibration monitoring system (see 3.1.69, note 2).

E.2 Signal Detection Schemes

Comment A SETPOINT UMM channel can be programmed to make any of the measurements discussed in this annex. See also comments to 7.4.4.5 and 7.4.4.6.

E.2.5.a Signal Detection Circuitry

Comment SETPOINT uses true peak and true RMS detection circuitry. RMS scaling to obtain derived peak is not used.

I.1.1 Setpoint Multiplier Factor

Comment The SETPOINT rack allows programmable values for the setpoint multiplier. It can be 2 or 3, as discussed in this paragraph, or any other integer or non-integer value. This value is individually programmable for each channel. When trip multiply is not used for a channel, its value is set to 1.

I.1.2 Invoking Setpoint Multiplication

Comment External contact closure invokes setpoint multiplication on a rack-wide basis. When multiple machine trains are included in a single rack, it may be necessary to invoke the feature individually for each train. This requires use of the MODBUS communications link as discussed in 4.13.2.n. where individual channels or groups of channels can be invoked separately.

I.5.3 Proper Selection of Setpoint Multipliers

Comment See comments to I.1.1. The ability to assign any value to a setpoint multiplier (not just integer values of 2 or 3) helps facilitate the intent of this paragraph.

I.6.3 Timer

Comment A DIN-rail mounted external timer relay is available upon request when a suitable machine control system output is not available. This relay can be programmed for any desired elapsed time before it resets.

I.6.4 Manually Invoking Setpoint Multiplication

Comment See comment to I.6.3 above.

N.1 Condition Monitoring - General

Comment In the SETPOINT Machinery Protection System (MPS), condition monitoring functionality is fed by machinery protection circuitry, not vice-versa. SETPOINT CMS communications utilize completely separate busses and networks in the rack than are used by machinery protective functions. Thus, the MPS is not compromised or impeded in any way by the CMS.

N.2 Condition Monitoring - Scope

Comment While tightly integrated SETPOINT MPS and CMS functionality (i.e., where both functions reside in the same instrument rack) is preferred by most customers, some customers have network security practices that require entirely separate hardware chassis for MPS and CMS, interconnected only via analog signals – not digital. Such instances are addressed by supplying two racks and using the buffered outputs of the MPS to drive the inputs of the CMS. Because identical hardware is used for both systems, spare parts requirements are minimized.

N.3.2 Data Sources

Comment The SETPOINT CMS system uses the OSIsoft PI System® as its database infrastructure. Although the data sources listed in paragraphs b-e do not originate in the machinery protection system, they are often present in the DCS and/or the plant data historian (which is often the PI System). The PI System has more than 400 available fully engineered interfaces for data from many disparate sources, helping to ensure that all of these data sources can easily be brought together into an integrated condition monitoring environment. Even when the plant data historian is not the PI System, a PI Interface will almost always exist to provide easy integration of the data into the condition monitoring environment.

N.9.2 Static Data

Comment The SETPOINT CMS system provides static data from every measurement returned by every UMM channel every 80ms. The user may configure so-called "deadbands" on this data such that change between one static value and the next which does not exceed a predefined limit will not be saved. The user may also turn off these compression settings such that deadbands are not used at all. This provides completely flexible control over the amount of data that is stored.

N.9.3 Dynamic Data

Comment The SETPOINT CMS system samples each and every waveform from every connected channel *continuously*. During any 5 second interval, all of these waveforms are compared against the previously collected baseline waveform, and only the waveform representing the most change from the baseline is stored for a channel. Deadbands can be established, similar to static data, such that only waveforms exhibiting sufficient change are stored, preserving mass storage space without missing relevant data. A maximum elapsed time setting can also be established such that forced storage of a waveform will always occur, even if the deadband criteria has not been satisfied. Thus, during changing conditions (such as a machine startup or process upset), waveforms will be gathered at rapid rates (up to once every 5 seconds) and during steady-state conditions, waveforms will only be saved at a user-configurable interval (such as once per day).

N.11.6.3 Antifriction Bearing Fault Frequencies

Comment A UMM channel in the SETPOINT system can be configured for rolling element bearings. This channel type provides six discrete bandpass regions for monitoring as follows:

- Overall (unfiltered) vibration
- ORBP (Outer Race Ball Pass frequency)
- IRBP (Inner Race Ball Pass frequency)
- Cage Frequency

- BSF (Ball Spin Frequency)
- 2x BSF

N.11.12 Gear Defect

Comment SETPOINT CMS provides rich timebase and spectrum tools. The circle plot visualization of Figure N.23 is not available at this time, but may be implemented in subsequent releases of the software. All of the data necessary to generate this plot is captured in the SETPOINT CMS database.

N.13.2 Data Acquisition for Dynamic Signals

Comment SETPOINT provides 24-bit A/D conversion and 105 dB of dynamic range. Magnitude accuracy is typically 0.3% of full scale.

N.13.2.3 Spectra Sampling

Comment SETPOINT collects and stores all data as time-series waveforms. Spectrums are extracted from the time-series data on-the-fly, such as when generating a half- or full-spectrum plot. Resolution, Frequency Range, and Sample Rate are fully configurable.

N.13.2.3.c Runout Compensation

Comment Data can be compensated using vectors (amplitude and phase) or waveforms.

N.13.2.5 Hanning Window

Comment Multiple window types (Hanning, Blackman, and Hamming) are available for spectral data presentation formats and can be changed on the fly.

N.13.2.6 Anti-Aliasing Filters

Comment Asynchronous data uses anti-alias filtering. Synchronous data does not use anti-alias filtering as the sample rate can be set as a fixed multiple of shaft rotating speed. See also comments to N.14.2.c.

N.13.2.14 Peak Impact Detection

Comment SETPOINT UMM channels can be configured for acceleration enveloping.

N.14.1 Waveform Sampling Types

Comment SETPOINT simultaneously samples both asynchronously and (when phase trigger is available) synchronously. See also comments to N.13.2.3.

N.14.2 Synchronous Sampling

Comment The SETPOINT system is fully configurable for synchronous sampling.

a) Sample rates of up to 128X per shaft revolution

b) Sample lengths of up to 128 shaft revolutions

c) Synchronously sampled data does not use anti-alias filtering

d) X-Y probe pairs are simultaneously sampled with their corresponding phase reference.

f) Band-pass filtering is available for 1X, 2X, and nX (user-defined) bands. Depending on channel type, up to 8 nX bands may be available. Band-pass filtering may be set as high-pass or low-pass filtering by selecting appropriate filter corners.

g) When orthogonal transducer pairs are available, both half- and full- spectrum plots can be viewed. When probe pairs are not available, only half-spectrum is available.

N.16.2.a Cursor

Comment A cursor is available on all plot types and can be turned on or off individually for each plot.

N.16.2.b Manual and Auto Plot Scaling

Comment Manual plot scaling is fully configurable. All plots can be toggled between manual and automatic scaling.

N.16.3.a Amplitude and Phase Recommendations

Comment SETPOINT capabilities are fully compliant with paragraphs a-d.

N.16.4.3 Frequency Domain Analysis

Comment Waterfall and Cascade plot types are fully configurable with up to 256 spectra per plot. Spectral frequency can be expressed in Hz, cpm, or orders.

N.16.4.4 Time Waveform Analysis

Comment Filtered (1X, 2X, nX) and unfiltered timebase and orbit plots are supported. Both vector and waveform runout compensation is supported. Time synchronous averaging is not supported at this time.

N.16.4.5 Critical Speed Analysis

Comment Bode, polar, shaft centerline, and gap voltage plots are fully supported.

N.16.4.6 Trend Analysis

Comment The SETPOINT CMS system uses the OSIsoft PI System as its database infrastructure. While the CMS Display client supports rich trending and analysis tools, the OSIsoft PI ProcessBook client supports an even larger palette of display and analysis tools for trends.

N.17.1.1 Basic Data Storage for Normal Operation

Comment See comments to N.9.2 and N.9.3. All data types described in N.17.1.1 a-e fully supported.

N.17.1.1 Detailed Data Storage for Normal Operation

Comment The interval for data storage even when no discernible changes have occurred is fully configurable, and can be set from once every 1 minute to once every 10,000 minutes (approximately 7 days).

N.17.3 Data Storage for Start-up/Coastdown

Comment Fully compliant. Static data capture occurs every 80 ms, regardless of machine rotative speed. Dynamic data capture occurs whenever a waveform attribute changes by more than a configurable percentage (i.e., outside of a deadband). These waveform attributes include overall amplitude, 1X amplitude, 2X amplitude, gap voltage, bandpass region amplitudes (if configured), and rotative speed change (i.e., $\triangle$ rpm). The $\triangle$ rpm setting can be configured in 1 rpm increments, independent of all other deadband settings. See also comments to N.9.2 and N.9.3.

N.17.4 Data Storage for Known Machine Problem

Comment The SETPOINT system uses the concept of deadbands for both static and dynamic data, and these deadbands can be set independently of one another. By using deadbands, it is not necessary to know in advance what type of malfunctions will occur, to rely on hardware alarms in the MPS, and to know what type of data sampling rates each one merits. Instead, the maximum allowable percent of change (i.e., the "deadband") for any waveform attribute is configured in the system as discussed in comments to N.17.3. The system then automatically detects and captures any waveform data that has been characterized as "interesting" based on these deadband criteria. A waveform's "interestingness" is known as its i-value, and this i-value technology (patent applied for) differentiates SETPOINT from other systems that rely on hardware alarms and alarm buffers, startup/shutdown buffers, and tedious requirements to set software alarms on individual spectral frequencies. Important data is never missed, and unchanging data does not consume storage space.

N.17.5.2 Static Data Storage

Comment See comments to N.9.2.

N.17.5.3 Dynamic Data Storage

Comment See comments to N.9.3.

N.17.5.4 Transient Data Storage

Comment Fully compliant. See also comments to N.17.3. Archived transient data can bookmarked as an "event" for baseline reference and comparison to other collected startups and shutdowns. A "live" mode allows transient data to be collected and displayed as it occurs, in real time. A playback mode allows previously stored data to be played back at normal and fast-forward speeds, tracing out plots such as polar and Bode, and showing associated waveforms as they change.

N.17.5.5 Continuous Display of Dynamic Signals

Comment Live mode capabilities are identical to stored data capabilities, update rates, and resolution.

N.17.5.7 Live Mode Data Storage and Printing

Comment Live mode data is automatically stored to disk; no special intervention is required. All stored data can be displayed and printed. It can also be exported to Microsoft Excel and other environments using the import/export capabilities native to the OSIsoft PI System using tools such as PI DataLink.

N.17.5.7 Remote Access

Comment A very significant benefit of using the OSIsoft PI System as the infrastructure for SETPOINT CMS is the inherent security model resident in the PI System. Database mirroring, use of data diodes, and other advanced capabilities are available in the PI System that may not be available in other systems, consequently rendering them unable to securely support certain types of remote access (such as from the internet). For more information, visit www.osisoft.com and enter "security" in the search box to find the hundreds of available resources on PI System security.

N.19.4 Baseline Data

Comment Along with highly secure remote access, another very significant benefit of using the OSIsoft PI System as the infrastructure for SETPOINT CMS is the archival capabilities. It is not necessary to separately store the baseline data of paragraphs a-j. All data, whether displayed or not, is stored continuously without special intervention from the user. The user need only bookmark the data later to characterize it with a descriptive name, such as "initial post-overhaul startup." The PI System has excellent capabilities for data archival and retrieval. It is also agnostic with regards to the visualization tools used to display the archived data. The PI System is also extremely proficient in its ability to store data with the right amount of compression (or no compression). As the price of mass storage continues to drop, the tradeoffs between storage space and data resolution continue to diminish. The PI System's flexibility ensures that it can continue to adapt to these changes in storage technology and costs.

N.19.7 Enhanced Monitoring of Troubled Machines

Comment A fundamental difference in SETPOINT CMS is the use of data "interestingness" to trigger dynamic data storage (see comments to N.17.3 and N.17.4). Other systems rely on either hardware alarms in the MPS (see N.20.1.2), supplementary (and usually manually configured) software alarms in the CMS (see N.20.1.3), and pre-defined △ rpm settings (see N.17.3) to trigger CMS data capture. In contrast, SETPOINT CMS uses the concept of data "interestingness" to trigger waveform collection, along with the ability to use hardware alarms, software alarms, and △ rpm settings.

N.20 Alarm Settings

Comment SETPOINT CMS allows the user to manually establish software alarms. It also allows the user to create calculated variables by combining measured values in the PI System database, and alarm on these calculated variables. However, a significant difference in the SETPOINT CMS system is that it does not require the user to establish all of these software alarms to obtain value from the system or to trigger when data capture will occur. All of this occurs *automatically* in the system using the i-value technology discussed in our comments to N.17.4. Default values trigger on any 3% change in waveform attributes, and these values have empirically shown to be effective for most machines and scenarios. However, they can be easily adjusted in the field to optimize data collection to the unique characteristics of a machine where required.

N.20.4.2 Alarm Response Instructions for Operators

Comment SETPOINT CMS can use the PI Notifications feature of the PI System, whereby specific instructions can be transmitted to operators for specific alarm conditions. The PI Advance Computing Engine (PI ACE) is also a standard feature in all PI Server software that allows supplementary logic and calculations to be developed for smart alarming based on user-configurable criteria.

N.21.2 Data Types for Analysis

Comment The assumptions in paragraphs a-c are rooted primarily in data collection architectures that date back to the 1980s where there were three discrete modes of data acquisition: steady-state, pre- and post-event collection surrounding hardware alarms, and data collected during transient conditions (where transient only meant changes in machine rotative speed). SETPOINT CMS does not divide data capture into these categories. Instead, it automatically collects data only when sufficient change has occurred in any waveform parameter – not just △ rpm changes or hardware alarms. In fact, hardware alarms have little relevance under the SETPOINT data collection scheme, as the software no longer has to be externally instructed when to collect or freeze data by way of an MPS relay or digital alarm. Instead, the CMS functionality samples everything, detects any change exceeding a user-configured threshold level, and stores the data based on its interestingness. A conventional system defines interestingness using only *two* criteria: hardware alarms and changes in machine speed. SETPOINT CMS defines interestingness using *many* criteria:

- Overall amplitude
- Waveform period (i.e. machine speed)
- Gap (bias) voltage.
- 1X filtered amplitude
- 2X filtered amplitude
- nX filtered amplitude (up to 8 nX values)
- amplitudes within user-defined bandpass, low-pass, or high-pass regions

SETPOINT CMS also allows the user to configure a "max elapsed time" setting that ensures dynamic data will always be collected during a certain △ time interval, even when none of the above-mentioned waveform criteria have changed sufficiently. Static data is always collected every 80 ms, regardless of steady-state, transient, or alarm events.

N.21.4 Data Analysis

Comment While much of the content in Annex N is devoted to specialized plot types unique to rotating machinery analysis, the importance of trend analysis should not be overlook. Because the SETPOINT CMS system uses the PI System as its database, all of the powerful trend visualization tools that have been developed surrounding the PI System (such as PI ProcessBook and PI Coresight) are available to supplement the trend visualization capabilities in the CMS display application itself. In addition, the ability to compare vibration trends with process trends are no longer limited to only the data within the CMS system. Instead, data correlation capabilities are limited only by the data types resident in the PI System, which will often be a very large plurality of process and non-process measurements, sometimes numbering into the hundreds of thousands of points. These capabilities are native to the PI System and do not have to be replicated in the CMS.

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