vibro-meter

MEGGITT

THE SPEEDOMETER

OVERSPEED

A NATURAL PROGRESSION IN AN UNCHANGING MISSION

With our founding in 1952, vibro-meter established itself as one of the very first companies devoted to machinery protection solutions. We've never looked back.

As our expertise and scope expanded over the intervening 70 years, it remained focused on this core competence of machinery protection, embracing not just industrial machinery, but demanding aerospace applications as well. It was only natural that we move beyond the measurement of rotating parts to include fixed components like gas turbine combustors, providing customers with truly asset-wide solutions. And, with such strong ties to machinery protection, it was only natural that we would expand our scope to include more than just speed indication by introducing an innovative and highly capable speed protection product line as well. We hope you find the pages that follow educational – making the topic of overspeed protection both understandable and approachable.

CONTENTS

WHEN EVERY MILLISECOND COUNTS

Why does an overspeed system have to be so fast and just how fast is "fast enough"?

In a blink...

At first glance, it might seem that a massive turbomachinery rotor – often weighing tons – simply could not accelerate fast enough to go from its rated speed to a speed fast enough for the rotor to disintegrate in the blink of an eye. But that's all the time it takes.

How is this possible?

From 100 to 0...

First, consider that a turbine driving a load can undergo a near-instantaneous loss of load. For example, if a breaker opens on a generator the turbine can go from a full-load to no-load condition in just a few electrical cycles or a mere *one-twentieth* of a second. No matter how good the primary speed control governor may be, it is generally not designed to act this fast. The same thing can happen in a mechanical drive turbine if a coupling shears, causing the mechanical load to be abruptly lost.

Megawatts of power with nowhere to go...

Next, consider that the machine is driving that load with substantial amounts of power, often measured in not just kW but perhaps hundreds of MW in the case of a large steam turbine generator train or tens of MW in the case of a mechanical drive for a compressor train. Everyone knows the sensation of pushing on an object that they thought would be heavy, only to find it is light – you might stumble or fall down entirely because force is exerted against something with nearly no opposing resistance. Your body accelerates very quickly in the pushing direction. The rotor in a rotating machine is no different.

Let's skip the math...

Then, consider the rotational inertia of the driving machine's rotor and the so-called rotor time constant. Although the equations are somewhat complex and will not be repeated here, they can be found, for example, in Annex O of API 670 for typical non-reheat steam turbines. They can also be found in papers[1] [2] presented at the 2003 Turbomachinery Symposium. Suffice to say here that for a typical turbine, the rotor time constant is anywhere from 2 to 5 seconds, and that the entire shutdown loop should generally be designed to act within one-tenth of that time. In other words, anywhere from 200ms to 500ms. It is thus very typical for the acceleration of a rotor that sustains instantaneous loss of load to accelerate from rated running speed to 120% of running speed in less than half a second.

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[1] Rutan, C.R., 2003, "Turbine Overspeed Trip Protection" *Proceedings of the Thirty-Second Turbomachinery Symposium*, Turbomachinery Laboratory, Texas A&M University, College Station, Texas, pp. 109-120.

[2] Smith, S., Taylor, S, 2009, "Turbine Overspeed Systems and Required Response Times" *Proceedings of the Thirty-Eighth Turbomachinery Symposium*, Turbomachinery Laboratory, Texas A&M University, College Station, Texas, pp. 157-167.

But, but, but...

"But", you may say, "half a second is still 500 milliseconds. Why does every millisecond count? Aren't you exaggerating? And why such a small margin (20%) in allowable maximum rotational speed?"

Fair questions. Let's take them one at a time.

The effect of exponent 2...

First, the forces acting on a rotating shaft with its components are directly related to the square of the speed. Thus, a 3600 rpm machine operating at 120% of rated speed (4320 rpm) does not simply sustain 20% more force on its blades, impellers, or windings – it sustains 44% more force. At these forces, machines begin to come apart. The sanitized, clinical term used by the industry is "blade liberation" but what this really means is that blades come loose from the rotor and become projectiles – often puncturing the case and releasing high-pressure steam, threatening people and property. Even if the liberated blade itself does not strike a person, the release of steam can result in injury to anyone unfortunate enough to be nearby whether on the same side of the machine or not. Nor is this limited to so-called "turbomachinery" operating at high speeds. It can also affect slow-moving machinery such as hydro turbine-generators rotating at speeds 60 times slower than a 3600 rpm steam turbine-generator. When a hydro turbine comes apart, massive flooding can occur such as occurred during Russia's Sayano-Shushenskaya hydroelectric dam disaster. Although not an overspeed event, it shows just how serious the destruction of a turbine can be. In that particular incident, 75 people lost their lives. A hydro turbine overspeed event could easily result in a similar level of damage.

10% – not 20%...

Next, consider that most overspeed trip system are set to activate at 110% of rated speed – not 120%. This is because the system must start acting before the rotor speed reaches 120% to ensure that it never reaches 120%. Thus, the entire system must be able to act in the window of time between the rotor reaching 110% of rated speed and 120% of rated speed. This typically reduces the available time to just 100ms during which the overspeed detection system must take action and the energy must be removed from the turbine to stop it from accelerating.

before

after

Although the Sayano-Shushenskaya hydroelectric dam disaster was not due to overspeed, **it shows the consequences of a catastrophic turbine failure and the resulting damage of hydraulic forces** from the unconstrained water. Pieces of a massive generator rotor can be seen in the foreground and in the oil-saturated water.

It takes time...

Removal of energy from the turbine does not occur the instant that the overspeed system closes its trip relay. Instead, the entrained energy (typically steam) already in the piping will expand through the turbine and continue to accelerate the rotor. In some cases, there is so much steam between the valve and the turbine that the turbine will accelerate beyond 120% even if the overspeed detection system could respond in zero milliseconds! In such cases, the steam valve must be placed closer to the turbine (as close as possible). In other cases, it can remain where it is but detracts from the time available for the overspeed system to act.

The need for speed...

The industry has generally settled on a maximum response time for the overspeed detection system of 40ms, as contained in industry standards such as API 670, but the required response time can be much shorter depending on the application. Everything has to be considered – the time for the overspeed detection system to act, the time for the valve to close, and the time for the entrained energy to fully deplete itself through the turbine. Although that's a very short time for everything to occur, the overspeed system itself must act faster than you can blink your eye – and that's no exaggeration. *

"It takes approximately **300 milliseconds** to blink your eye. That's nearly **ten times** longer than the time allowed for a typical overspeed detection system to act"

THE INSURER'S PERSPECTIVE

The people that insure industrial plants and machinery have a unique perspective on overspeed events because they are the ones who must often pay for the ensuing damage.

This includes not only the direct costs related to repair and/or replacement of machinery, piping, instrumentation, and other subsystems, but also the costs associated with lost production and business interruption. Here, we explore that perspective and why it matters.

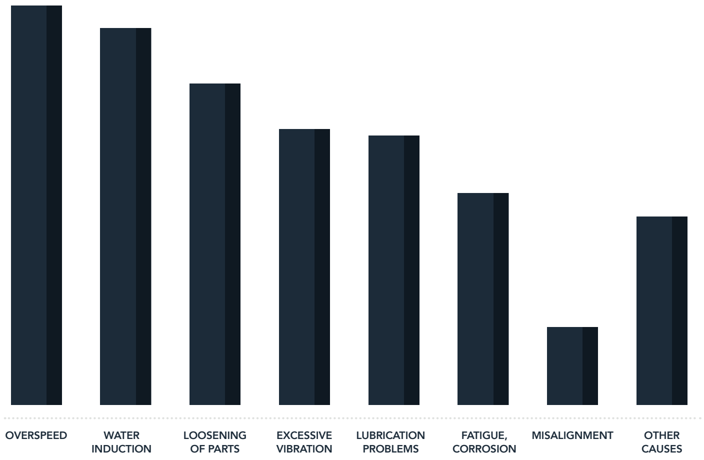
Numerous insurance and re-insurance companies exist globally to provide coverage for industrial plants and constituent machinery assets, whether fixed, rotating, or reciprocating. The data they compile is particularly valuable because it spans different industries, different machine types, and different types of failures – providing insight into not only what the failures are, but how costly they are relative to other types of failures. One well-known insurer – Hartford Steam Boiler (HSB) – is the largest provider of mechanical breakdown and industrial all-risk insurance in the world, and thus their database of industrial losses is both highly influential and highly relevant. They took the time in the mid-1990s to provide insight into such questions and the data they shared is quite revealing.

Of all loss types across all industries using steam turbines, overspeed events were the most costly.

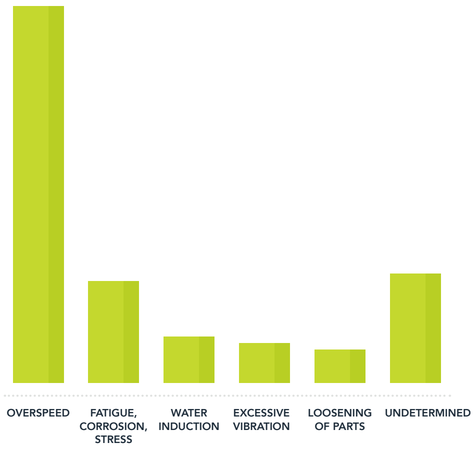
The data spanned the period 1980 to 1995 and although that may seem quite dated, it actually fits perfectly into a discussion of electronic overspeed detection systems because up until 1995, many companies were still using mechanical overspeed bolts instead of electronic systems. Thus, although the migration to electronic systems was indeed underway, the data reflected what a world largely dependent on mechanical overspeed apparatus looked like from an actuarial standpoint.

Relative Size of Average Loss

All industries

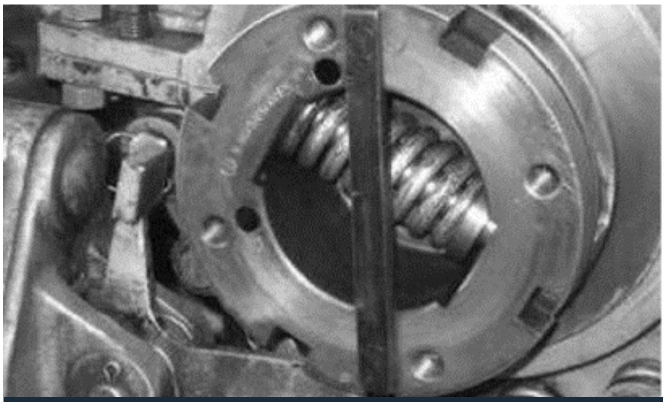


Oil, Gas and chemical sector



Hartford Steam Boiler data collected from 1980 to 1995 for the seven most common causes of steam turbine damage across all industries (top) **showed that overspeed was the most costly type of event.** In the oil, gas, and chemical sector (bottom), **the data was even more compelling.**

While the data showed that overspeed events were not the most *frequent* compared to other types of damage-causing events (excessive vibration was the most common), overspeed was the most *costly*. A vice-president at Starr Technical Risks put it this way: "From a property insurance viewpoint, an overspeed event can destroy the case of a steam turbine and/or the driven [machine]. Since cases are not typically carried as spare parts, an overspeed event can result in a very large business-interruption insurance claim, in addition to a claim for the cost of the destroyed steam turbine and its driven [machine]."



A mechanical bolt such as this is no longer the preferred approach by the insurance industry for overspeed protection.

It should not be surprising, then, that insurers have a definite stake in what type of overspeed protection is used and thus have very clear recommendations. Here's what three well-known insurers have to say:

"For many years, I have advocated replacing mechanical governors and mechanical overspeed protection devices with electronic governors and electronic overspeed protection systems. The electronic governor and electronic overspeed detection system must be installed in strict accordance with API 612 and API 670."

- Edward Clark (retired), HSB

"If your steam turbine has a mechanical hydraulic overspeed trip device, it is recommended that the trip device be replaced with an electronic overspeed system."

- AIG (Client Risk Solutions "Insight", Sept 2017)

" A large steam turbine uncontained overspeed event can produce forces approaching those of a large plane crash. A single last-stage turbine blade can exert more than 300,000 pounds of force at synchronous speed. A 2013 Electric Power Research Institute paper titled "Steam Turbine Electronic Overspeed Protection System" advocates trip system conversion to an electronic overspeed protection system, in part for the advantages of lower-speed functional testing. We endorse robust electronic overspeed protection systems where testing can be performed without imposing potentially destructive rotor forces."

- AEGIS Insurance Services, Inc. (May 2021 White Paper)

Clearly, the consensus is that an electronic system is warranted not just for new machines, but for retrofit on existing machines to reduce risk

If you're thinking only about missed trips to ensure an overspeed event doesn't destroy your machine, you're considering only half the picture. Here's why you need to be concerned with false trips, too.

When it comes to overspeed, a missed trip is often catastrophic. No wonder it's most people's first concern. But should it be your only concern?

Consider what a system would look like if your only concern was truly missed trips. Let's assume the probability of a missed trip for a simplex system is 1 in every 100 demands placed upon the system ($PFD_{avg} = 0.01$). Let's now add a second system and further assume that there are no common-cause failures between the two systems – they have separate sensors, separate power supplies, and let's even go so far as to say they were designed by two entirely different companies, but both systems have the same PFD_{avg}. If we allow either system to trip the machine (i.e., logical OR voting), our joint probability becomes 0.01 x 0.01 = 0.0001 or one in ten thousand.

In fact, under such a scheme we can keep adding separate systems while employing OR voting to make the probability of a missed trip vanishingly small. And if safety was our only concern, that is exactly the approach we might use as the probability of a missed trip in the above example becomes 1×10^{-2n} where n is the number of systems. If we wanted a system, for example, that would only fail (on average) once in every *one million* demands placed upon it, we would need only to use three such systems, connected in an OR voting arrangement.

But in the real world, of course, it is not just a missed trip that incurs costs and business disruption – false trips (i.e., spurious trips) can likewise introduce costs.

First, it may not be possible to immediately restart the machine if it is a very large steam turbine. Or, if a mechanical drive turbine, the process disruption might be considerable as not just the machine, but the process must come back on line. Then, there is the cumulative wear and tear that each trip and restart incurs on many machines with the associated mechanical and thermal stresses.

So, what are we to do? At one extreme, by employing logical AND instead of OR voting we could dramatically decrease the probability of a false trip (also known as a spurious trip rate or STR) . Indeed, AND voting means that a false trip will only occur if all n systems falsely agree to trip when it is not warranted. Meanwhile, however, by employing AND voting, we have now insisted that all n systems must be working simultaneously and vote "true" in order to trip our machine, and thus the probability of a missed trip goes up: a failure in any *one* of the n systems can prevent a trip. Previously, only a *single* system out of n needed to be working to trip the machine. Now, *all* n systems need to be operational and the probability is obviously less than if we only require a single system to be operational.

We address this in practice by using so-called "m-out-of-n" voting. For example, most SIL 3 applications will employ a 2-out-of-3 voting arrangement between three redundant systems. Such an arrangement balances missed trips (PFD_{avg}) with false trips (STR) to arrive at an acceptable compromise. The topic is dealt with in greater detail in informative Annex M contained in API 670: *Considerations Regarding Spurious Shutdowns and the Use of Functional Safety Methodology to Reduce Economic Losses.* *

Voting Arrangement	PFD_{avg}	Spurious Trip Rate (STR)
1oo1	3.3×10^{-2}	4.5×10^{-6}
1oo2	1.4×10^{-3}	9.0×10^{-6}
2oo2	6.6×10^{-2}	2.9×10^{-9}
2oo3	4.3×10^{-3}	8.7×10^{-9}

A numerical example of the relationship between missed trips (PFD_{avg}) and false trips (STR) for various voting arrangements using arbitrary baseline values in a 1oo1 arrangement. Notice that pure OR voting (1oo2) gives the best results for missed trips while pure AND voting (2oo2) gives the best results for false trips. However, by employing 2oo3 voting, an acceptable balance between the probability of both false trips and missed trips can be obtained.
Table courtesy of Kenexis Safety Engineering, Inc.[3]

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[3] Marszal, E. "Comparison of Voting Arrangements in SIS", Nov 2018, Kenexis Consulting Corporation

API 670

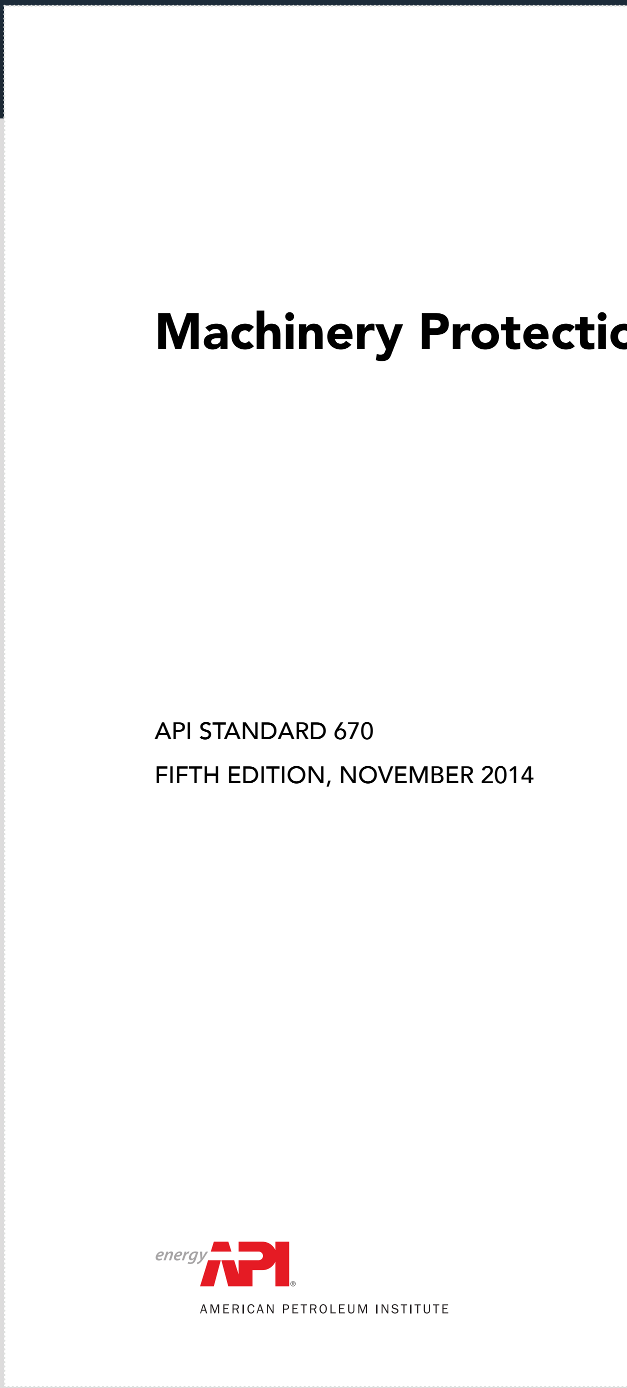
THE INDUSTRY STANDARD

Soon to be in its 6th edition, API 670 is where the world turns for its baseline of good engineering practice in electronic overspeed detection.

Since its initial release in June 1976, API 670 has evolved considerably. Today, it encompasses a comprehensive approach to machinery protection consisting of vibration, bearing temperature, axial (thrust) position, compressor surge detection, emergency shutdown (ESD), and overspeed detection.

Overspeed was added to the standard with publication of the 4th edition in Dec 2000. Previously, much of the overspeed content had resided in API 612 (special-service steam turbines), but it was recognized that other machine types also required overspeed protection – not just steam turbines – and these included gas turbines, expander-compressors, and variable frequency drives (VFDs). The logical place to put overspeed content thus became API 670, a machinery-agnostic standard, where it could be easily applied to any machine by simply citing it rather than repeating all the requirements in each individual API machinery standard such as 612, 616, and 617.

Today, the content has been expanded considerably and augmented with various Annexes that discuss sensor considerations, speed wheels for the sensors to observe,



Machinery Protectic

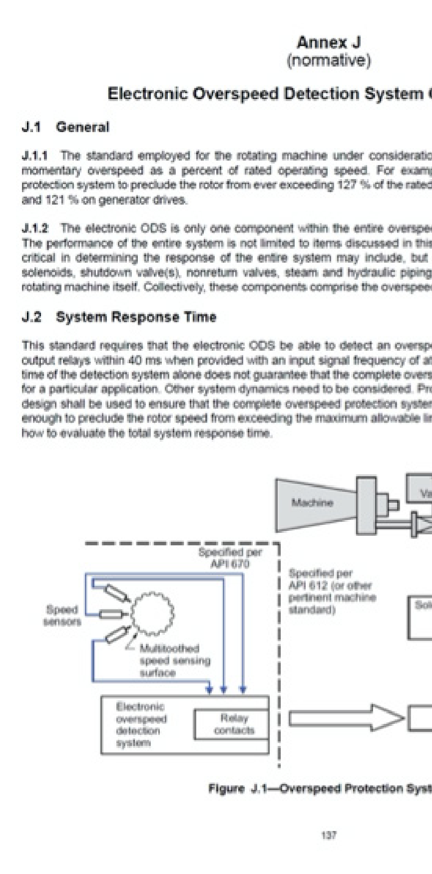
API STANDARD 670
FIFTH EDITION, NOVEMBER 2014

and the calculations used when computing maximum rotor speed. Although the standard specifically targets the rotating and reciprocating machines used in the petroleum industries, it is broad enough to encompass other industries and is indeed used by power generation customers and others – particularly for overspeed. This is because there is currently no comparable standard that is so thorough in defining the requirements of such a system as well as numerous options that allow the system to communicate and interact with other systems, yet without impeding its response time or protective integrity.

The standard defines numerous characteristics including the need for redundant power sources, the types of mechanical relays used and their ratings, the types of digital interfaces that must be available, and the requirement for SIL certification. It also specifies a number of best practices such as a requirement that it be entirely separate from the basic vibration monitoring system and that it not share the same speed sensors as the basic speed control governor – to prevent failure of speed sensors in one system from affecting the other, and that each machine train have its own dedicated overspeed protection system.

The standard also clarifies nomenclature, making a distinction between and overspeed *detection* system and an overspeed *protection* system. Namely, that the electronic overspeed detection system (eODS) is simply one part of the overall overspeed protection system (OPS) which consists of piping, interposing relays, valves, hydraulic systems, headers, and other apparatus such as final control elements.

Perhaps the best-known requirement of API 670, however, is that the eODS must have a response time of 40ms or better; however, if the calculations of Annex O dictate a faster response is required, then the system must perform accordingly – so 40ms is merely a starting point, not an ending point. Although suitable for many customers, there are many instances where even 40ms is not fast enough and a device with an even faster response time may be required. For example, the SpeedSys300 by vibro-meter boasts a 10ms response time from speed input to relay output.



Annex J
(normative)

Electronic Overspeed Detection System

J.1 General

J.1.1 The standard employed for the rotating machine under consideratio
momentary overspeed as a percent of rated operating speed. For examp
protection system to preclude the rotor from ever exceeding 127 % of the rated
and 121 % on generator drives.

J.1.2 The electronic ODS is only one component within the entire overspe
The performance of the entire system is not limited to items discussed in this
critical in determining the response of the entire system may include, but
solenoids, shutdown valve(s), nonreturn valves, steam and hydraulic piping
rotating machine itself. Collectively, these components comprise the overspee

J.2 System Response Time

This standard requires that the electronic ODS be able to detect an oversp
output relays within 40 ms when provided with an input signal frequency of at
time of the detection system alone does not guarantee that the complete overs
for a particular application. Other system dynamics need to be considered. Pr
design shall be used to ensure that the complete overspeed protection system
enough to preclude the rotor speed from exceeding the maximum allowable li
how to evaluate the total system response time.

Figure J.1—Overspeed Protection Syst

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When selecting and evaluating an overspeed system, API 670 is strongly recommended as a source of unbiased requirements. The task force responsible for generating and maintaining the standard consists of machinery OEMs, end users, specifiers (such as Engineering, Procurement, and Construction companies), safety consultants, machinery consultants, and manufacturers of 670-compliant sensors and systems. This diverse composition of participants ensures that the standard does not favor any particular supplier and truly represents the needs of users and other stakeholders while reflecting industry best-practice. *

Copies of API 670 can be obtained from the API Publications Store (www.techstreet.com/api) and then navigating to *API Publications Catalog >> Refining >> Mechanical Equipment Standards.*

WHY ALL THE FUSS?

Is an overspeed event really that bad?
What are the consequences if it doesn't work?
We'll let you be the judge.

A picture, as they say, is worth a thousand words so consider this collection of photos from the aftermath of a steam turbine-generator wreck at the Iranshahr Power Plant to be the ultimate commentary on the importance of selecting the right overspeed solution and maintaining it properly.

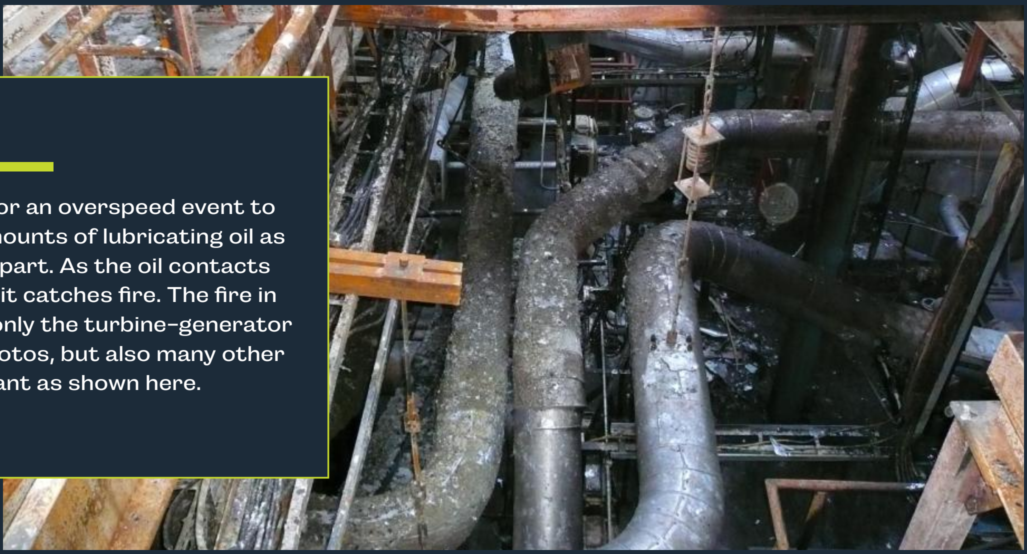
The Iranshahr Power Plant is located 25km west of Iranshahr, Iran and consists of a combined cycle plant built in 2011 and a conventional thermal plant built in 1996. Unit #3 in the thermal plant is the subject of these photos – one of four identical 64MW steam turbine-generators. A coupling failure in 2009 led to this catastrophic sequence of events.

This photo shows the section between the low-pressure turbine case on the left and the generator on the right. Notice that the shaft between the two is entirely absent. When the coupling failed, 64MW of mechanical restraining torque from the generator was instantaneously removed from the steam turbine. As a result, the turbine began accelerating out of control.

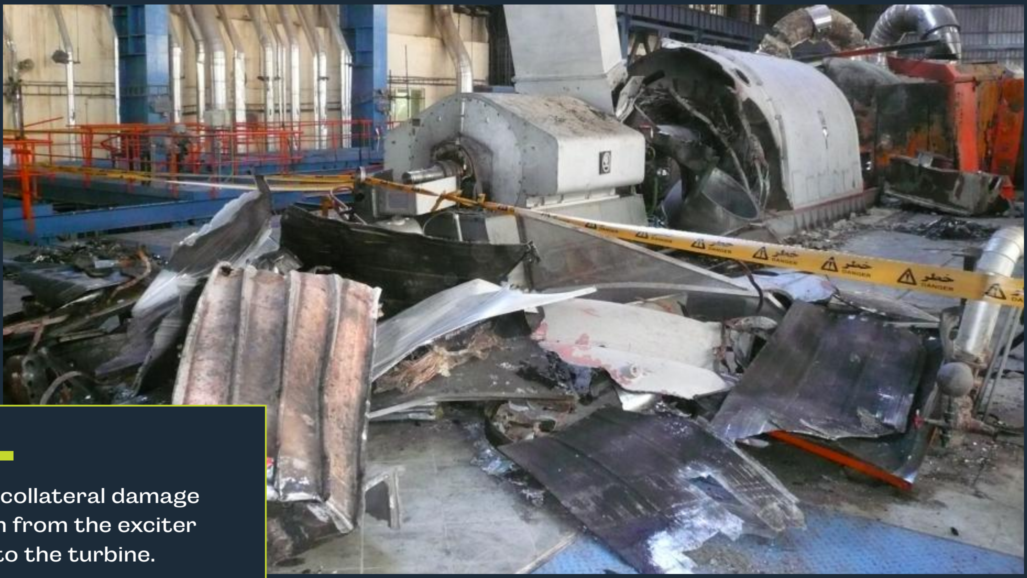
As it accelerated unrestrained, the protruding turbine shaft literally severed and became airborne. This photo shows the turbine side of the liberated shaft where it bolts to the coupling. It left the machine with such force that it flew across the plant, landing in the men's locker room. It is not known if any fatalities occurred, but clearly there were few safe areas anywhere in the plant if even the locker room was not immune from damage.

The bearing pedestal came completely dislodged from the foundation. It went one direction while the bearing covers went in other directions.

Parts of the machine became projectiles, puncturing the roof and interior walls.



It is not uncommon for an overspeed event to release substantial amounts of lubricating oil as the machine comes apart. As the oil contacts the hot steam piping, it catches fire. The fire in this event burned not only the turbine-generator as seen in the prior photos, but also many other parts of the plant as shown here.



This photo shows the collateral damage looking down the train from the exciter to the generator to the turbine.

API 670

THE GREAT BOLT REVOLT

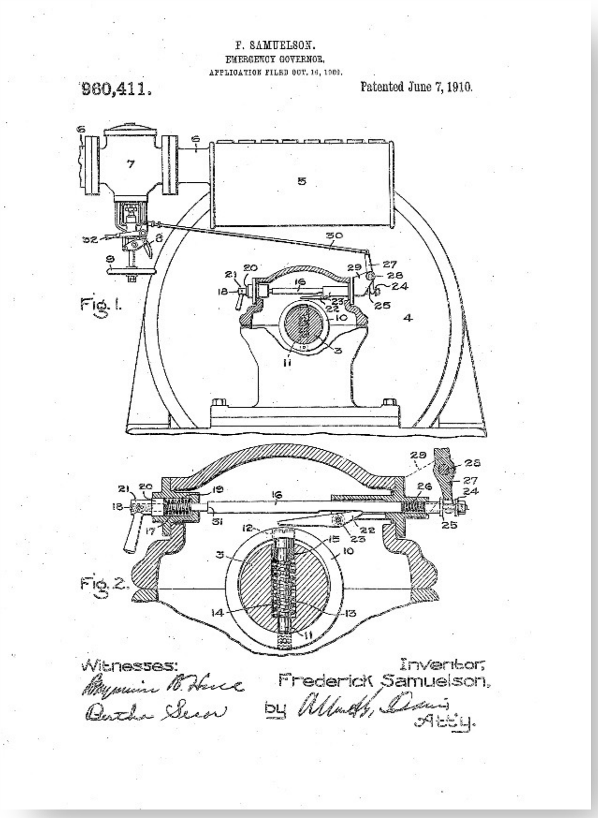
Why that mechanical bolt is no longer such a good idea

A reliance on century-old technology

The original patent for a mechanical overspeed bolt dates back to June 7, 1910 when it was issued to Frederick Samuelson of the General Electric Company. The idea was both ingenious and simple: a spring-tensioned bolt was mounted inside a rotating machine's shaft. At a predetermined speed, the centrifugal force of the rotating bolt would overcome its spring force and the bolt would protrude far enough from the shaft to contact a lever, removing energy (usually steam) from the machine and tripping it. That basic design would undergo refinements for the next 80 years, but the principle would remain the same.

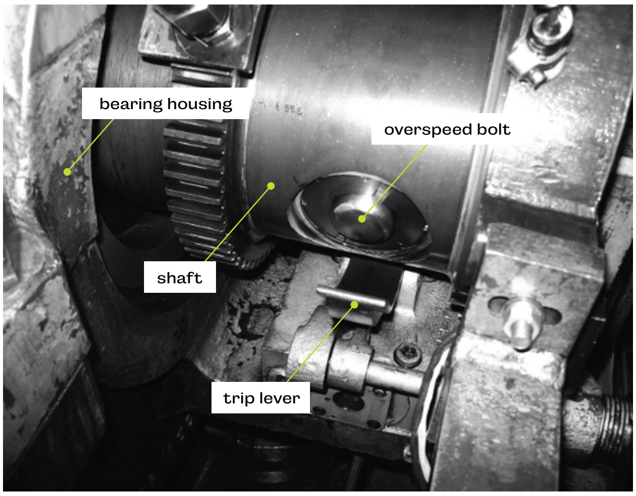
The good, the bad, and the ugly

Although the device had undoubtedly prevented countless overspeed events from occurring (along with the catastrophic damage that accompanies them), it was not without its problems. Bolts were notorious for sticking – becoming frozen in place though years of remaining in one position. Nor were bolts highly repeatable for the speed at which they would deploy and could vary widely based on radial vibration and other factors that combined with the spring force. Perhaps most



A cross-sectional diagram from Samuelson's original patent showing a spring-tensioned overspeed bolt. The invention was called an "emergency governor" referring to the fact that it was designed to work as an emergency device when the primary speed control governor failed to do its job.

concerning, however, was that the user was expected to test the operation of the bolt at regular intervals (yearly or ideally, every six months), but in order to test the bolt, the machine had to be placed into the very condition one was trying to avoid: overspeed. Thus, in order to prevent an unsafe situation, the machine had to be intentionally placed in an unsafe condition! The literature is abounding with examples of overspeed catastrophes that occurred precisely because the mechanical overspeed bolt was being tested but did not work. Ironically, testing the system was one of the most unsafe things the user could do.



A typical mechanical bolt and trip lever assembly from a power generation steam turbine.

Fast forward to the early 1990s

By the 1990s, electronic overspeed detection systems were becoming more commonplace and had the following advantages:

- They could be tested by simulating an overspeed signal, eliminating the need to put the machine into an unsafe condition.
- They could employ redundance so that while one circuit was being tested, the other circuits could continue to protect the machine.
- They could self-test at regular intervals rather than requiring human intervention
- Adjustment of setpoints could be done without stopping the machine to access a mechanical bolt and adjust the spring force
- There were no mechanical components associated with the detection system and thus no requirement for lubricating, adjusting, and mechanically servicing.
- The setpoint could be set very precisely and did not suffer from non-repeatability.

Pivoting to today’s technology

As a result, the industry began to migrate away from mechanical bolts in new turbines and numerous retrofit projects were launched to replace the mechanical overspeed bolts on steam turbines in mechanical drive service, steam turbines in power generation service, hydro-electric turbines, gas turbines, and any other machine for which overspeed could occur. Today, mechanical bolts are no longer a preferred solution for gas, steam, and hydro turbines and steam turbine standards such as API 612 no longer permit them.

The vibro-meter SpeedSys300 is an example of a modern electronic overspeed detection device that is SIL-rated and can be deployed in redundant configurations such as 2-out-of-3 voting for safe, accurate overspeed protection.

If you have machinery still using a mechanical bolt, now is the time to replace it with a modern, electronic overspeed detection system conforming to API standard 670. Not only is it safer but it can pay for itself quickly because the machine no longer has to be stopped to test the overspeed system, eliminating the associated downtime – whether planned or unplanned. It is also preferred by industrial insurers and will often result in lower premiums.

EVERYTHING YOU NEED FOR

OVER SPEED

The all-new SpeedSys300 from vibro-meter delivers API 670-compliant overspeed detection in a convenient DIN-rail package that is at once small yet enormously powerful.

Learn more in the pages that follow.

Completely capable

1 Overspeed, underspeed, and rate-of-change (acceleration) alarming

2 One non-safety output (frequency) for speed indication

3 Advanced self-monitoring and diagnostics: detects both sensor chain and module problems

4 4-20mA analog output (SIL-rated; suitable for safety applications)

5 Auxiliary (non-safety) output for speed indication

6 Ultrafast, 10ms response

7 Accepts eddy-current, hall-effect, and magnetic sensors

8 Galvanically separated speed inputs to support measurement chains in hazardous areas

9 SIL2 and SIL3 capable; certified by design

10 0.25 Hz – 35 kHz frequency response

11 API 670-compliant

12 Safety alarms drive two independent DPST relays (Relay 1 and Relay 2)

13 Front-panel LED status indicators

14 Password-protected configuration for enhanced cybersecurity

15 Non-safety alarms drive two independent SPST relays (Relay 3 and Relay 4)

16 10-year proof test interval

17 Redundant power inputs

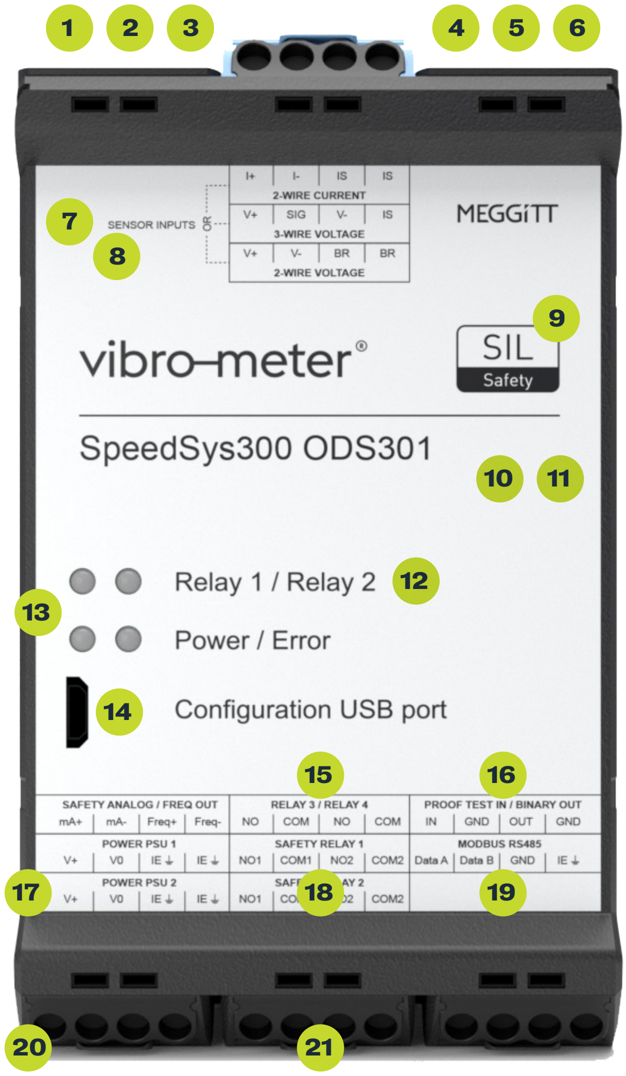
18 Four (4) independent alarm setpoints (two safety and two non-safety)

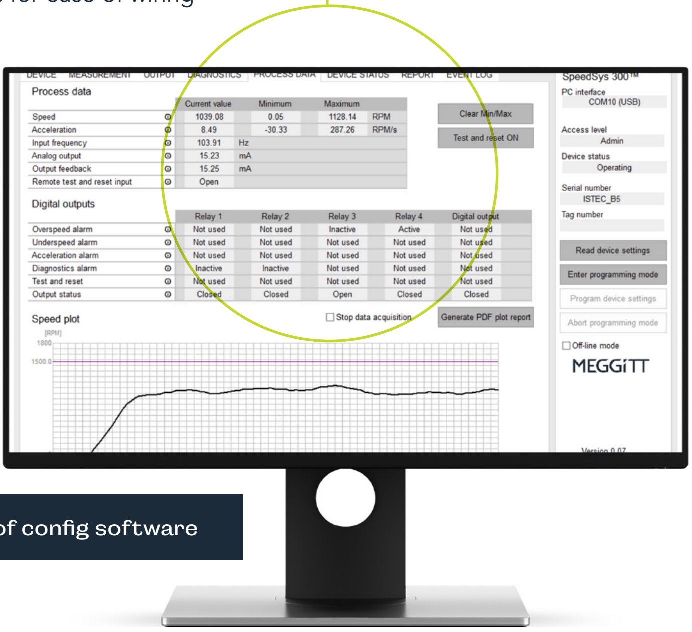
19 Modbus RTU serial data interface for connection to DCS, PLC, and other automation platforms

20 Compact size (188 x 117 x 68 mm)

21 Removable connectors for ease of wiring

22 Global approvals





Process data

	Current value	Minimum	Maximum	
Speed	1039.08	0.05	1128.14	RPM
Acceleration	8.49	-30.33	287.26	RPM/s
Input frequency	103.91	Hz		
Analog output	15.23	mA		
Output feedback	15.25	mA		
Remote test and reset input	Open			

Digital outputs

	Relay 1	Relay 2	Relay 3	Relay 4	Digital output
Overspeed alarm	Not used	Not used	Inactive	Active	Not used
Underspeed alarm	Not used	Not used	Not used	Not used	Not used
Acceleration alarm	Not used	Not used	Not used	Not used	Not used
Diagnostics alarm	Inactive	Inactive	Not used	Not used	Not used
Test and reset	Not used	Not used	Not used	Not used	Not used
Output status	Closed	Closed	Open	Closed	Closed

Speed plot

☐ Stop data acquisition

SpeedSys 300™

PC interface: COM10 (USB)

Access level: Admin

Device status: Operating

Serial number: ISTEC_B5

Tag number:

☐ Off-line mode

Version 0.07

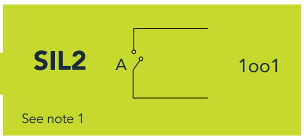
Screen capture of config software

22

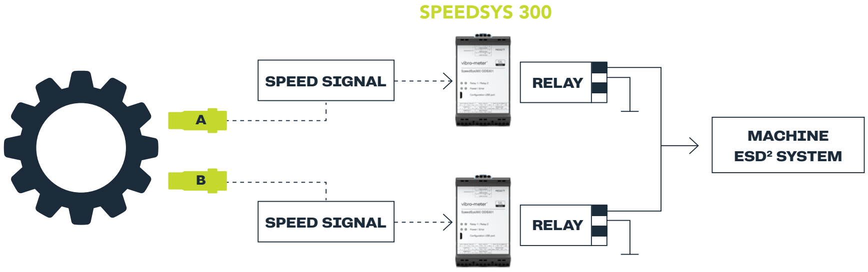
Completely flexible

For non-critical applications that can benefit from basic speed protection but do not require redundancy, a simple, single-loop solution can meet Sil 2.

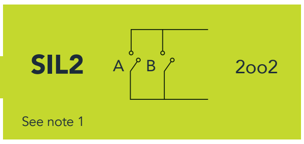
1oo1 for SIL2 in non-critical applications



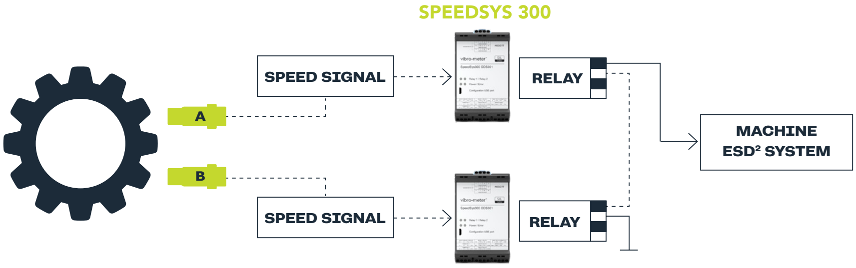
Adding a second SpeedSys300 and employing AND voting provides 2oo2 protection, retaining SIL 2 while reducing the likelihood of a spurius trip compared to an arrangement when only a single loop is used.



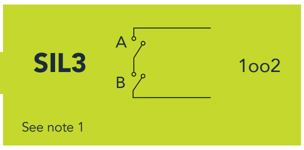
2oo2 for SIL2 with improved STR[3]



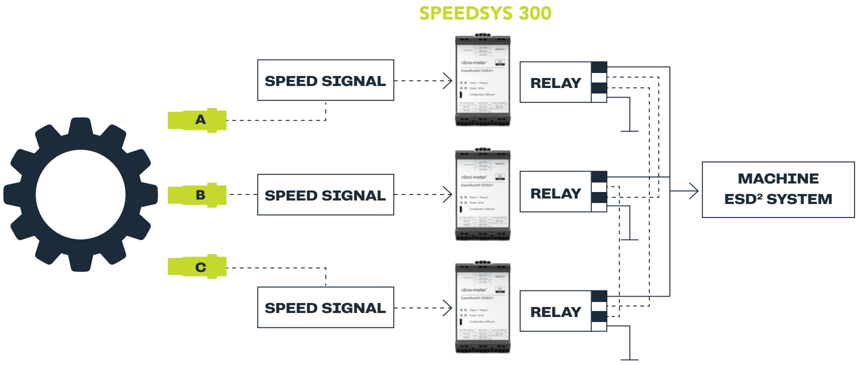
By employing OR voting instead of AND voting, two SpeedSys300 modules can better guard against missed trips because either system can now trip the machine during an an overspeed event. However, although 1oo2 voting reduces the likelihood of a missed trip and thus elevates the system configuration to SIL 3, it also elevates the likelihood of a spurious trip.



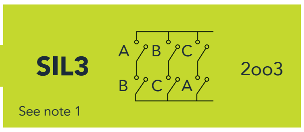
1oo2 for SIL3 and improved PFD_{avg}[3]



By moving to a 2oo3 arrangement using three SpeedSys300 modules, both false trips and missed trips can be optimally reduced without pitting one against the other as in other configurations. This arrangement is recommended for highly critical applications such as large steam turbines.



2oo3 for SIL3 and balanced PFD_{avg} / STR



Notes:

1) All relay depictions and wiring connections assume normally energized relays with contacts closed when channel is in non-alarm state.

2) ESD = Emergency Shutdown

3) See pages 9-10 for a detailed discussion of STR and PFD_{avg}

ENGINEERED

SOLUTIONS

While the SpeedSys300 may be at the core of our overspeed offerings, we know that most customers are not interested in a do-it-yourself box of parts. They need an engineered solution.

A solution that brings together all of the necessary components into an integrated, functional whole. Sensors, field wiring, overspeed detection devices, documentation, configuration, and the know-how to make it all work together in a SIL-rated environment that minimizes not just missed trips, but false trips.

We understand. That's exactly why we provide engineered solutions.

We also understand that OEMs and end users have different needs. OEMs want a solution that can be configured once and deployed across many identical or similar machines, delivering right-sized protection capabilities with a right-sized feature set, a right-sized price, rock-solid reliability, and SIL certification. End users want many of the same things, but often with special features to address the realities of incumbent machinery with special needs. When retrofitting, a physical package that fits in the same space as the old system is often important – and functionality that replicates the outgoing system while interfacing with minimal changes to existing control and automation equipment.

Our engineered solutions start with a deep understanding of your needs and a willingness to tailor our offering accordingly – whether you need something that will be replicated many times or something that is unique. Whether you have needs for measurements like creep detection on a hydro machine or reverse rotation on a machine with dry gas seals or a customized number of safety relays – in addition to basic overspeed functionality – our engineered solutions are designed to address such needs. And, they use standard building blocks for overspeed detection, logic solving, and local indication – all in a SIL-rated package that has the flexibility to accommodate any type of speed sensing input.

Contact your local vibro-meter sales professional today to learn more. *

- ✓ 1oo2 or 2oo3 configurations with support for up to 3 speed measurement chains
- ✓ Proximity, Hall-Effect, or Variable Reluctance (magnetic pickup) Sensors
- ✓ SIL3 capable in 2oo3 configurations; SIL 2 for 1oo2 configurations
- ✓ Available with or without Dynamic Control for global System Diagnostics
- ✓ Standard (2) or custom type and number of safety relays
- ✓ Standard (6) or custom type and number of auxiliary relays
- ✓ Standard (3) or custom type and number of analog outputs
- ✓ Standard (3) or custom number of individual frequency outputs (processed raw speed signal)

- ✓ **Redundant power supply inputs with options for 110VAC, 230VAC, and high-voltage DC supplies**
- ✓ **Local or remote HMI (speed indicators / system status)**
- ✓ **Digital communications with other control and automation platforms via industry-standard protocols**
- ✓ **Machine state-based capabilities via digital logic inputs**
- ✓ **Standard or custom faceplate to match existing mounting provisions and dimensions**
- ✓ **Reset button**
- ✓ **Proof Test button**
- ✓ **Standard or customized connectors**

INTEGRATION

WITHOUT RISK

Knowing the status of your overspeed system is vital – but without compromising its protective features or exposing it to cybersecurity vulnerabilities.

Many customers choose to wire the SIL-rated 4-20mA output into a separate PLC, SCADA, or DCS environment where it can conveniently display current speed from each SpeedSys300 module. And, because each safety relay is DPST, it can be wired to both the safety loop and an annunciation loop to ensure that when the safety alarms change state, the condition is conveyed securely.

The Modbus interface allows digital communications to retrieve the same current value and status data from the device as via analog means, but also provides rich additional data such as error codes and operating parameters such as peak speeds, acceleration rates, alarm setpoint values, and more. However, the Modbus interface does not expose the device to vulnerabilities – data can only be read via this interface and the device cannot be placed in test mode, setpoints cannot be changed, and configuration cannot be changed. Instead, this level of access can only be done by those with physical access to the device via its local USB port accompanied by the SpeedSys300 configuration software. Multiple SpeedSys300 units can be connected via a single Modbus RS-485 interface, and each can be programmed with a separate Modbus address allowing a single DCS communications gateway to address any connected SpeedSys300. *

Images on pages 13, 14 excerpted from API Standard 670, Machinery Protection Systems, Fifth Edition, Nov 2014. Reproduced with permission from the American Petroleum Institute.

MEGGITT

About us

Meggitt pioneered high performance sensing and condition monitoring solutions for extreme environments. After working with the world's turbine manufacturers for more than 60 years, Meggitt through vibro-meter portfolio remains master of all aspects of the condition monitoring and machinery protection disciplines.

From high performance sensing, data acquisition and management to the high speed digital networking and the signal processing algorithms that can deliver diagnostics for prescriptive maintenance solutions.

Meggitt PLC

Headquartered in the United Kingdom, Meggitt PLC is an international group operating in North and South America, Europe and Asia. Known for its specialised extreme environment engineering, Meggitt is a world leader in aerospace, energy and defence markets.

An 11,000-strong workforce serves customers from around 40 manufacturing facilities and regional offices worldwide.

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