

IEEE Recommended Practice for Monitoring and Instrumentation of Turbine Generators

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of the
IEEE Power Engineering Society**

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Abstract: A basic philosophy and guidelines are established for the design and implementation of monitoring systems for cylindrical-rotor, synchronous turbine generators. Monitoring systems are used to display the status of the generator and auxiliary systems while these systems are operating on line. The basic information needed to choose monitoring schemes best suited for each application is provided. This standard does not specify actual equipment or instrumentation, but it does indicate some critical areas where it is important to provide monitoring capability.

Keywords: cylindrical-rotor, synchronous turbine generators; turbine generators

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Foreword

(This foreword is not a part of IEEE Std 1129-1992, IEEE Recommended Practice for Monitoring and Instrumentation of Turbine Generators.)

This document is intended to establish a basic philosophy and guidelines for the design and implementation of monitoring systems for large turbine generators. Monitoring systems are used to display the status of the generator and auxiliary systems while on line. This document does not include automatic protective devices or relays.

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1. Scope and References

1.1 Scope. This document is intended to establish a basic philosophy and guidelines for the design and implementation of monitoring systems for cylindrical rotor, synchronous turbine generators. Monitoring systems are used to display the status of the generator and auxiliary systems while these systems are operating on line. This document does not specify actual equipment or instrumentation, but it does indicate some critical areas where it is important to provide monitoring capability.

Generator-protection techniques are not discussed in this document. There is a fine line of distinction between instrumentation that is used for monitoring and instrumentation used for protection, and there are many instruments that play a dual role.

The purpose of monitoring is to provide information to the operator to guide appropriate action. This action may be maintenance planning, maintaining load, tripping the unit, or load reduction. The key distinction between monitoring and protection is that with monitoring, the action taken (if any) is not automatic but is initiated by the operator. Some users may choose to include some of the items listed here as part of the generator-protection scheme.

Monitoring of basic generator parameters is routinely performed on commercial generators. It is only recently, however, that the economics of power generation has created the need, and advancing technology provided the ability, to monitor nearly all aspects of generator operation. This should allow the operation of large-capacity machines with increased reliability and availability and with reduced downtime for outages. However, care must be exercised to avoid “overmonitoring.” While there is no doubt that great quantities of data may be useful to review when (and if) time permits, the operator should not be subjected to an overload of unessential data. The use of diagnostic systems may facilitate handling of multitudinous data to assist the operator.

This document provides the basic information needed to choose the monitoring schemes that are best suited for each application. Not all items discussed in this document are necessary for all generators. Some users may wish to add additional monitoring systems beyond those presented in this document. The user should refer to the manufacturer’s monitoring recommendations.

1.2 References. This recommended practice shall be used in conjunction with the following publications. When the following standards are superseded by an approved revision, the revision shall apply.

[1] ANSI C50.13-1977, American National Standard Requirements for Cylindrical-Rotor Synchronous Generators¹.

[2] ANSI C50.14-1977, American National Standard Requirements for Combustion Gas Turbine Driven Cylindrical Rotor Synchronous Generators.

¹ANSI publications are available from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA.

[3] ANSI C50.15-1989, American National Standard Requirements for Hydrogen-Cooled Combustion Gas-Turbine-Driven Cylindrical-Rotor Synchronous Generators.

[4] IEEE Std 67-1990, IEEE Guide for Operation and Maintenance of Turbine Generators (ANSI).²

[5] IEEE Std 421.1-1986, IEEE Standard Definitions for Excitation Systems for Synchronous Machines (ANSI).

[6] IEEE Std 492-1974 (Reaff 1986), IEEE Guide for Operation and Maintenance of Hydro Generators (ANSI).

[7] IEEE Std C37.101-1985 (Reaff 1990), IEEE Guide for Generator Ground Protection (ANSI).

[8] IEEE Std C37.102-1987 (Reaff 1990), IEEE Guide for AC Generator Protection (ANSI).

2. Definitions

monitoring. The process of observing a system to verify that its parameters are within prescribed limits.

particulate. A small particle that is created by thermal decomposition of organic materials present inside the generator.

protection. The process of observing a system, and automatically initiating an action to mitigate the consequences of an operating condition that has deviated from the established acceptable performance criteria.

pyrolysate. A product of thermal decomposition.

stator bar. A unit of winding on the stator of a machine. *Also:* bar; stator coil.

3. Stator Frame and Core

Stator frames of turbine generators have been very reliable in making minimal contributions to forced outage rates. Some early-on problems with vibration and alignment have occurred, usually in conjunction with foundation, soleplate, and grouting deficiencies. The monitoring emphasis has been very low for this component of the generator. However, concerns for internal components occasionally arise with respect to core overheating, local overheating due to short circuits between adjacent core laminations, and excessive tooth vibration.

3.1 Frame

3.1.1 Presence of Liquids or Moisture. The presence of liquid in the generator may be evidence of a cooler leak, leak of a water-cooled stator winding component, or seal oil entry. Moisture-laden hydrogen gas supply could also be a source of the water, as well as simply the

²IEEE publications are available from the Institute of Electrical and Electronics Engineers, Service Center, 445 Hoes Lane, P. O. Box 1331, Piscataway, NJ 08855-1331, USA.

operation of a unit with a low cold gas temperature, which may cause condensation. Air-cooled units that use ambient air may be susceptible to condensation under some conditions. The biggest risk may be when the unit is in cold shutdown, and warm moist air enters the stator.

Moisture entering the lubricating oil system from the turbine gland steam seals may also be released into the generator from the hydrogen seal oil system.

Accumulation of liquids can seriously jeopardize the proper operation of the generator. Leaking liquids can quickly fill the generator terminal box, causing phase or ground faults, or block the flow of cooling gas.

Generators are provided with several drain lines located at low spots in the generator frame and stator core center region. These drain lines may be fitted with liquid level detectors with alarms, and with sight glasses for visual observations. Drain lines must be arranged so that the liquid reaches the detector.

The level of the unit's gas-borne moisture content may be monitored by electronic dew-point or humidity monitors, or by periodic sampling. The dew point of the inlet and outlet gas of the gas dryer may be monitored in order to determine dryer efficiency.

3.1.2 Frame Vibration. Frame vibration may be evidence of poor rotor balance, rotor misalignment, unequal rotor heating, material loss or fracture of rotating parts, improper bearing loading or displacement, poor grouting, or uneven frame foot loading.

Frame vibration may also be the result of excessive core vibration (see 3.2.7), unequal operation of the coolers, or core vibration transferred to the frame. High frame vibrations are sometimes observed due to frame resonant responses to rotor rotational, or core ovalizing frequencies. Structural damage to frames and cores may occur.

Some manufacturers have pedestal-mounted bearings, so any rotor misalignment may not affect frame vibration.

A change in coupling between core and frame may also affect vibration.

Many stator cores are structurally isolated from the frame and foundation by heavy springs. The adequacy of frame weight distribution on the foundation greatly affects frame vibration. An indication of poor frame foot loading may be derived from seismic transducers incorporated with journal-bearing vibration monitors. A means of monitoring this acoustically is sometimes employed.

The monitoring instrument should be capable of detecting vibration at rated and double frequencies.

3.2 Core

3.2.1 General Overheating. A general increase in the core temperature beyond the normal full-load temperature can be caused by an increase in the cold gas temperature, a load output above the normal full-load point, a reduction in gas pressure, deterioration of hydrogen purity, or an increase in gas cooling water temperature. It may also be caused by a flow restriction, such as damper or cover plate, or a bypass around the gas flow circuit.

General core overheating can be measured by thermocouples (TC) embedded in the core at several locations. Monitoring of the hot gas temperature and gas pressure also provides good information about the core temperature condition.

3.2.2 Local Overheating. If the generator is being operated in the underexcited, leading power factor region of the capability curve, the resulting flux distribution may create higher losses, particularly in the stator iron at the ends of the core. The higher losses in turn create higher temperatures. The load should always be limited to points within the capability curve to ensure that the core temperature limit is not exceeded. Operation in the overexcited, lagging power-factor region is preferred in minimizing stator core end temperatures. As a backup, particularly for larger machines, the stator core temperature may be monitored. Core temperatures should not be utilized as the sole basis for machine operation.