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GE Energy

Hydrogen Cooling System

7FH$_2$ GENERATOR

These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes the matter should be referred to the GE Company.

The below will be found throughout this publication. It is important that the significance of each is thoroughly understand by those using this document. The definitions are as follows:

NOTE

Highlights an essential element of a procedure to assure correctness.

CAUTION

Indicates a potentially hazardous situation, which, if not avoided, could result in minor or moderate injury or equipment damage.

WARNING

INDICATES A POTENTIALLY HAZARDOUS SITUATION, WHICH, IF NOT AVOIDED, COULD RESULT IN DEATH OR SERIOUS INJURY

*****DANGER*****

INDICATES AN IMMINENTLY HAZARDOUS SITUATION, WHICH, IF NOT AVOIDED WILL RESULT IN DEATH OR SERIOUS INJURY.

I. INTRODUCTION

These instructions cover the principal features of the generator that are incident to the use of hydrogen instead of air as the cooling medium. They are supplementary to the instructions given for the installation, operation and maintenance of the turbine generators.

II. ADVANTAGES OF HYDROGEN COOLING

Hydrogen is used in place of air as the cooling agent principally because of its low density and its superior cooling properties. Since its density is approximately one-fourteenth the density of air at a given temperature and pressure, the use of hydrogen reduces the windage friction losses of a rotating machine to a small fraction of the losses encountered when running in air. For a high-speed machine such as a turbine-generator, this results in an increase in full-load efficiency of between ½ and 1%. Hydrogen has a thermal conductivity of nearly seven times that of air, and its ability to transfer heat through forced convection is about 50% better than that of air. This permits a reduction of nearly 20% in the amount of active material required in the construction of a generator of given output and for a given temperature rise of the windings.

The life of the generator is increased by operating in hydrogen. This is because the enclosed construction keeps out dirt and moisture from the windings and ventilation passages. Also, with hydrogen, there is practically no deterioration of the armature insulation because of corona.

Since additional kilovolt-ampere output may be obtained by increasing the hydrogen pressure, the $7FH_2$ generators have a maximum hydrogen pressure rating of 45 psig [310 kPa (gauge)][3.16 kg/cm^2 (gauge)]. At increased pressures the hydrogen becomes more dense, and this improves its capacity to absorb and remove heat.

As a result, additional load may be carried with no increase in the temperature rise of the windings. Also, increasing the hydrogen pressure permits operation at normal load with the temperature of the water supplied to the gas cooler in excess of normal. In general, an increase in kilovolt-ampere output of about 1% may be obtained for every 1-psi [6.9-kPa][70-g/cm^2] increase in hydrogen pressure up to 15 psig [103kPa(gauge)][1.05 kg/cm^2 (gauge)], while for pressure between 15 and 30 psig [103 to 207 kPa (gauge)][1.05 to 2.11 kg/cm^2 (gauge)], an increase in output of about ½ % per psi [6.9 kPa][70 g/cm^2] of an increase in pressure may be obtained. For operation at rated output with temperatures of the cooling water in excess of normal, it is permissible to increase the inlet water temperature by approximately 1°F (0.56°C) for each 1-psi (6.9-kPa) (70-g/cm^2) increase in hydrogen pressure up to 15 psig [103 kPa (gauge)][1.05 kg/cm^2 (gauge)]. For hydrogen pressures from 15 to 30 psig [103 to 207 kPa (gauge)][1.05 to 2.11 kg/cm^2 (gauge)], an increase of about 0.5°F (0.28°C) in water temperature per psi (6.9 kPa) (70 g/ cm^2) increase in pressure is permissible.

III. GAS COOLERS

The gas is circulated through the generator in a closed system. The heat absorbed by the gas in passing over the surfaces of the stator and rotor is removed while passing over the finned tubes of five gas coolers provided in the stator frame. The coolers, through which water is circulated, are located within the stator casing. They are arranged with their long axes horizontal, along the bottom of the stator frame. Removal of cover plates at either end of the coolers permits access to the cooler tubes for cleaning.

WARNING

SERVICING OR REPAIRING THE COOLER WHILE THE GENERATOR IS OPERATING WITH HYDROGEN IN THE CASING IS EXTREMELY HAZARDOUS AND SHOULD NOT BE ATTEMPTED.

IV. HYDROGEN COOLING EQUIPMENT

Subsequent articles in this manual will furnish more details regarding the equipment used in hydrogen cooling. However, the system basically consists of the shaft sealing arrangement and the gas equipment.

The shaft sealing components consist of an oil source, pumps, regulators and an alarm system.

The gas equipment consists of hydrogen, under pressure, along with the necessary instruments to control the gas and to analyze the purity. Associated with the hydrogen equipment is an arrangement whereby carbon dioxide, under pressure, is used to purge the generator casing when changing from air to hydrogen, or vice versa.

V. SAFETY PRECAUTIONS

Under normal operation in hydrogen, the atmosphere in the generator will be nonflammable. However, a mixture of between 5 and 75% hydrogen in air will explode if ignited in an enclosed space. To ensure complete safety of operation of the hydrogen-cooled generator, a hydrogen purity approximately between 95 and 98% is maintained in the generator casing at all times, thus making an explosion within the casing normally impossible.

When completely assembled and operated in the proper manner, the generator housing, which forms the hydrogen container, will be a gas-tight, self-ventilated enclosure strong enough to limit the destructive effects of an explosion of the hydrogen contents to the generator frame, housing and enclosed parts.

The hydrogen equipment of the generator is so arranged that ample ventilation is provided for the parts from which hydrogen leakage to atmosphere may occur. Care should be taken, however, to ensure that any hydrogen discharged from the various valves opening to atmosphere is not allowed to collect in enclosed spaces.

An open flame in a region in which hydrogen may be discharged should be avoided.

VI. OPERATION OF GENERATOR WITH AIR

If the generator is operated at any time with air instead of hydrogen as the cooling medium, a dry air supply should be connected to the generator casing and a small outward flow of air through the two scavenging lines maintained to ensure that oil from the shaft seals will not be drawn into the generator casing as a result of the increased fan suction in air. The shaft seals must be supplied with oil, as for the operation of the generator in hydrogen, in order to provide lubrication for sealing rings.

The dry air is to be supplied to the unit through a gas dryer (if furnished with the unit) or other suitable drying equipment. Maintain approximately between 1 and 5.0 psig [6.9 to 34 kPa (gauge)] [70 to 352 g/cm^2 (gauge)] of casing pressure in the generator when operating in air.

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