GE Power Systems

GE Generator Rotor Retaining Rings: Experience and Fleet Data

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SUMMARY

GE has recommended that all industrial and utility operators with generators that have 18 Manganese-5 Chromium (18Mn-5Cr) retaining rings replace those rings with those made from 18 Manganese-18 Chromium (18Mn-18Cr) material. Until these rings are replaced, they should be inspected, protected and repaired to minimize the possibility of their in-service failure.

This paper is an update for customers regarding new findings and inspection results for nonmagnetic 18Mn-5Cr retaining rings. These findings include the following key facts:

- All GE 18Mn-5Cr retaining rings inspected since 1991 using eddy current techniques have been found to have stress corrosion cracking and/or pitting
- The inside surfaces of the 18Mn-5Cr retaining rings have been found to be much more vulnerable to stress corrosion cracking. As a result, these surfaces should be inspected along with the outside surfaces to minimize the possibility of an in-service failure

Discussion:

Technical Information Letter 1001-3, issued in 1986, recommended replacing large steam turbine generator and MS7001 gas turbine generator 18Mn-5Cr retaining rings. TIL 1097-3, issued in 1991, recommended replacing all industrial and utility 18Mn-5Cr retaining rings for all generators not covered by TIL 1001-3. Since these TILs were issued, 55% of the GE generators listed on TIL 1001-3 have had their retaining rings replaced; 25% have been replaced for those GE generators on TIL 1097-3. The decision to replace these rings was based primarily on the high percentage of rings found to have stress corrosion cracking during an inspection.

Since issuance of these TILs, there have been at least three confirmed instances of in-service failures of 18Mn-5Cr retaining rings. In all cases, significant damage was incurred by the generators which resulted in an expensive generator rebuild and extended forced outage. It has been confirmed that prior to the ring bursts, two rings that failed were inspected and found free of stress corrosion cracking.

Most utilities that have not replaced their 18Mn-5Cr retaining rings continue to inspect these rings. However, inspection data continues to confirm that the 18Mn-5Cr material is extremely susceptible to stress corrosion cracking. In fact, since 1991, no 18Mn-5Cr retaining rings that have been inspected on both inside and outside surfaces using a combination of eddy current and fluorescent penetrant techniques has been found to be free of stress corrosion cracking and pitting.

Recent results have consistently shown that the inside diameter of the retaining rings is much more vulnerable to stress corrosion cracking. In general, 18Mn-5Cr retaining rings that have been inspected from the outside diameter with the retaining rings in place have not been found to have a large number of indications.

This is for a number of reasons.

First, the outside diameter does not have the locking key grooves and retaining ring insulation to trap and hold moisture and contaminants.

Also, the inside diameter is inspected with the ring in place using ultrasonic techniques which has a reliable repeatability limit of approximately 0.050 inches. As a result, most small (0.005 to 0.050 inch) indications are missed. It should also be noted that many retaining rings are painted on the outside surface (Figures 1, 2, 3 and 4).

When the cooling flow for the generator field is examined, it becomes apparent why the inside diameter of the field is more vulnerable. The cooling medium (air or hydrogen) is directed under the retaining rings from both ends of the field and contaminants and moisture can be

trapped under the retaining rings. The only way to ensure that 18Mn-5Cr retaining rings do not have stress corrosion cracking or pitting is to inspect all surfaces of the rings using eddy current and fluorescent penetrant techniques (Figures 5 and 6).

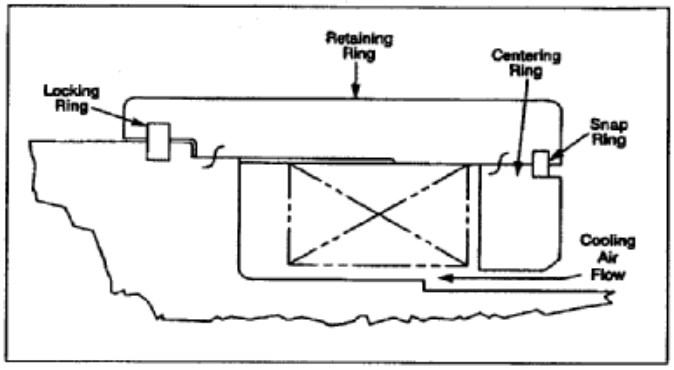

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Figure 1. Body-mounted retaining ring assembly

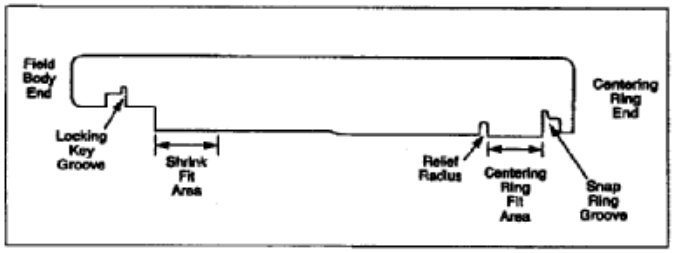

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Figure 2. Typical body-mounted retaining ring

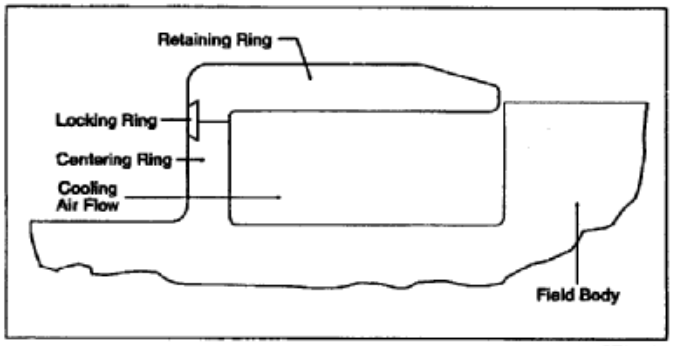

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Figure 3. Spindle-mounted retaining ring assembly

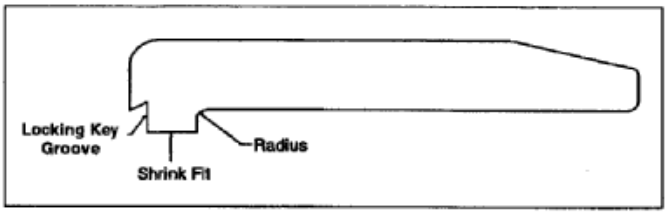

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Figure 4. Typical spindle-mounted retaining ring

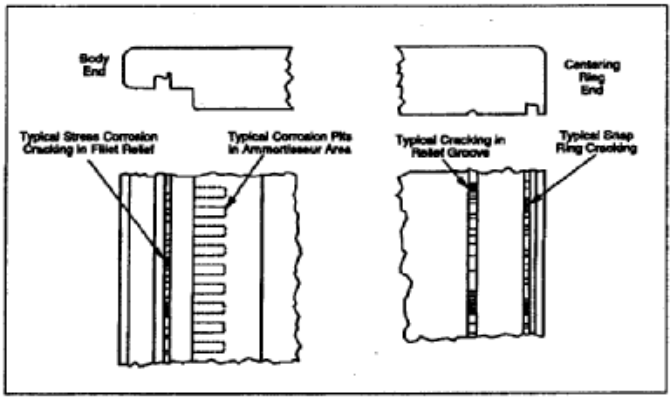

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Figure 5. Body-mounted retaining ring schematic; typical indications found on inside diameter of rings

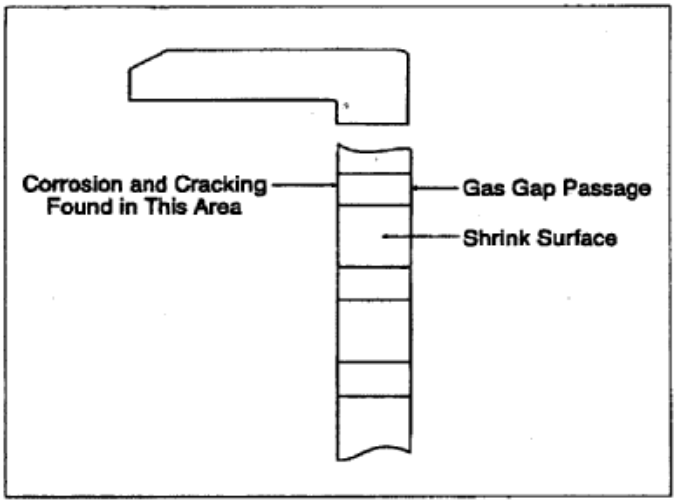

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Figure 6. Spindle-mounted retaining ring; typical indications found on inside diameter

Generator Fleet Data

The following tables summarize the inspection results for tests performed on GE 18Mn-5Cr retaining rings.

Table 1 data encompass all reported large steam turbine-driven generator retaining ring inspections from the first incident in 1982 to February 1995. It should be noted that, as a result of optimization of nondestructive testing (NDT) techniques for this application and development of experience by the inspectors of the characteristics and likely locations of retaining ring stress corrosion defects, some of the early inspections were not as reliable or as detailed as those performed today. It is therefore likely that the exposure in Table 1 is understated.

Table 1
RETAINING RING INSPECTION
LARGE STEAM TURBINE
GENERATOR EXPERIENCE

- 1982 through February 1995
  314 rings inspected
- Results
  42 replaced
  206 repaired
  66 no action
- 79% required replacement or repair

The data in Table 2 is similar to that of Table 1 except that it is for the medium generator fleet and is for the time period of January 1989 to February 1995. The data shows that 73% of the rings required replacement or repair as compared to 79% for the large steam generator fleet. This may be explained by the fact that the medium sized generator data includes inspections for quite a few more rings that were not removed from the field, so that possible cracks on the ID were not identified.

Table 2
RETAINING RING INSPECTION
MEDIUM GENERATOR EXPERIENCE

- 1989 through February 1995
  238 rings inspected
- Results
  55 replaced
  119 repaired
  64 no action
- 73% required replacement or repair

The medium generator data is broken down into rings which were removed from the field for inspection and those that were not, as shown in Tables 3 and 4. For those retaining rings which received only an outside diameter inspection, only 27% required repair and none required replacement. On the other hand, for those rings that received a complete inside and outside diameter inspection, 91% required replacement or repair. As stated earlier, this difference can be explained by the fact that the inside diameter can trap and hold moisture and contaminants in locking key grooves and under retaining ring insulation, whereas no moisture and contamination can be trapped on the outer diameter (OD) surface.

Table 3
RETAINING RING INSPECTION
MEDIUM GENERATOR RINGS
REMOVED FROM FIELD

- 1989 through February 1995
  172 rings inspected
- Results
  55 replaced
  101 repaired
  16 no action
- 91% required replacement or repair

Table 4
RETAINING RING INSPECTION
MEDIUM GENERATOR RINGS NOT
REMOVED FROM FIELD

- 1989 through February 1995
  66 rings inspected
- Results
  0 replaced
  18 repaired
  48 no action
- 27% required replacement or repair

It should also be noted that the outside surface of medium sized air-cooled generator retaining rings is normally painted. Although this provides protection for the painted surfaces, it gives a false sense of security for the unprotected inside surfaces. This leads to the conclusion that a complete inspection of all retaining ring surfaces is vital. This is particularly true for those retaining rings that have their outside diameter painted.

Tables 2, 3 and 4 relate to all medium generator 18Mn-5Cr retaining rings. Many times the question is asked whether the inspection results for retaining rings on generators powered by gas turbines are similar to those for steam turbine driven units, since these units are operated and maintained differently. By referring to Tables 5 and 6, one can see that the percentage of rings requiring replacement or repair for gas turbine driven generators (79%) is consistent with the inspection results for the entire 18Mn-5Cr retaining ring fleet.

Table 5
RETAINING RING INSPECTION
GAS TURBINE RETAINING RING EXPERIENCE

- 1989 through February 1995
  86 rings inspected
- Results
  30 replaced
  38 repaired
  18 no action
- 79% required replacement or repair

Table 6
RETAINING RING INSPECTION
ALL 18Mn-5Cr RETAINING RINGS

- 1982 through February 1995
  552 rings inspected
- Results
  97 replaced
  325 repaired
  130 no action
- 76% required replacement or repair

Table 6 is a summary of the inspection results for all GE 18Mn-5Cr retaining rings. It should be noted that this data includes all inspection results, regardless of whether the rings were removed.

Overall, the inspection results show that the vast majority of 18Mn-5Cr retaining rings have experienced stress corrosion cracking and pitting. As inspection techniques have been improved, an increasingly high percentage of 18Mn-5Cr retaining rings have been found to have stress corrosion cracking and pitting. Again, all retaining rings that have been inspected with eddy current since 1991 have been found to have stress corrosion cracking and pitting. The only way to eliminate this problem is to replace these rings with those made from the 18Mn-18Cr material.

Recommendations

- Replace all 18Mn-5Cr non-magnetic retaining rings with rings made from the 18Mn-18Cr non-magnetic material at the next planned maintenance outage. Stress corrosion cracking has and will continue to occur until these 18Mn-5Cr rings are replaced.
- In the interim, inspect, protect and repair 18Mn-5Cr retaining rings per the recommendations of TILs 1001-3 and TIL 1097-3. To ensure the best confidence of a ring being stress corrosion free, the entire retaining ring, both inside and outside diameters, should be tested using eddy current and fluorescent penetrant techniques. It should be noted that even if an 18Mn-5Cr retaining ring is found free of stress corrosion cracking, experience has shown that there is no guarantee against subsequent stress corrosion cracking and an in-service retaining ring failure.

REFERENCES

1. GER 3549A - Generator Rotor Retaining Rings: An Updated GE Perspective.
2. GEA 12212 - Eddy Current Testing
3. GEA 11996 - In-service Retaining Ring Inspection - Ultrasonic Testing

For further information, contact your GE Field Sales Representative or write to GE Power Systems Marketing

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