

CLAIMS:

1. A method of detecting pre-quench conditions in a superconducting magnet comprising an HTS field coil, the field coil comprising:
 - 5 a plurality of turns comprising HTS material and metallic stabilizer; and
 - a conductive material connecting the turns such that current can be shared radially between turns via the conductive material;the method comprising:
 - 10 monitoring strain of the HTS field coil and/or support structures of the HTS field coil;
 - comparing the monitored strain to an expected strain during normal operation of the magnet;
 - 15 in response to said comparison, determining whether the field coil is in pre-quench conditions.
2. A method according to claim 1, wherein the expected strain during normal operation is calculated dynamically based on operating parameters of the magnet.
3. A method according to any preceding claim, wherein determining whether the field coil is in pre-quench conditions comprises one or more of:
 - 20 determining that the field coil is in pre-quench conditions if the monitored strain exceeds the expected strain by more than a threshold value;
 - determining that the field coil is in pre-quench conditions if the monitored strain has a component perpendicular to the expected strain with a magnitude greater
 - 25 than a threshold value.
4. A method according to claim 3, wherein the or each threshold value is a predetermined proportion of the expected strain.
5. A method according to any preceding claim, wherein the magnet comprises a plurality of HTS field coils, and the determination as to whether each HTS field coil is in pre-quench conditions is based on measurements of the strain sensors corresponding to that HTS field coil and to the other HTS field coils.

6. A method according to any preceding claim, wherein the magnet comprises a plurality of HTS field coils, and the expected strain of each HTS field coil of the plurality of HTS field coils is based on monitored strain of at least one other HTS field coil of the plurality of HTS field coils.
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7. A method of detecting pre-quench conditions in a superconducting magnet comprising an HTS field coil, the field coil comprising:
- a plurality of turns comprising HTS material and metallic stabilizer; and
 - a conductive material connecting the turns such that current can be shared
- 10 radially between turns via the conductive material;
- the method comprising:
- monitoring a magnetic field of the HTS field coil;
 - comparing the monitored magnetic field to an expected magnetic field during normal operation of the magnet;
- 15 in response to said comparison, determining whether the field coil is in pre-quench conditions.
8. A method according to claim 7, wherein the expected magnetic field during normal operation is calculated dynamically based on operating parameters of the magnet.
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9. A method according to claim 7 or 8, wherein determining whether the field coil is in pre-quench conditions comprises one or more of:
- determining that the field coil is in pre-quench conditions if the monitored
- 25 magnetic field exceeds the expected magnetic field by more than a threshold value;
- determining that the field coil is in pre-quench conditions if the monitored magnetic field has a component perpendicular to the expected magnetic field with a magnitude greater than a threshold value.
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10. A method according to claim 9, wherein the or each threshold value is a predetermined proportion of the expected strain.
11. A high temperature superconducting, HTS, magnet system comprising an HTS
- 35 field coil, the HTS field coil comprising:

a plurality of turns comprising HTS material and metallic stabilizer;
a conductive material connecting the turns, such that current can be shared
between turns via the conductive material;

the HTS magnet system further comprising a quench protection system and one or more
5 strain sensors located on the HTS field coil or on a structural support of the HTS field
coil;

wherein the quench protection system is configured to:

monitor strain measurements of the one or more strain sensors;

compare the strain measurements to an expected strain during normal operation
10 of the magnet;

in response to said comparison, determine whether the field coil is in pre-quench
conditions

12. A high temperature superconducting, HTS, magnet system comprising an HTS
15 field coil, the HTS field coil comprising:

a plurality of turns comprising HTS material and metallic stabilizer;

a conductive material connecting the turns, such that current can be shared
between turns via the conductive material;

the HTS magnet system further comprising a quench protection system and one or more
20 magnetic field sensors;

wherein the quench protection system is configured to:

monitor magnetic field measurements of the one or more magnetic field sensors;

compare the magnetic field measurements to an expected magnetic field during
normal operation of the magnet;

25 in response to said comparison, determine whether the field coil is in pre-quench
conditions

13. An HTS magnet system according to claim 11 or 12, wherein the conductive
material is contained within a partially insulating layer comprising any of:

30 an intermittent layer of insulation;

a semiconductor;

a metal strip having an intermittent layer of insulation on each side; and

a metal-insulator transition material.

14. A tokamak comprising an HTS magnet system according to any of claims 11 to 13, wherein a toroidal field coil or poloidal field coil of the tokamak comprises the HTS field coil.