# REQUIREMENTS FOR STAR GLOBAL INTERLOCKS

# REQUIREMENTS FOR STAR GLOBAL INTERLOCK SYSTEM

*W.B. Christie*

*Brookhaven National Laboratory*

*CSN0361B*

Last revision June 14, 1999

This document defines and describes the requirements for the STAR Global Interlock System. Parts of this document are based on the contents of the document, *Requirements of Safety Interlocks for the STAR Detector*, by R. Jared *et al*.

## 1. INTRODUCTION

This document describes the requirements for the STAR Global Interlock System (SGIS) for the STAR detector system, which will be installed in an experimental hall at RHIC. It is intended to provide information on the background and fundamental requirements that are necessary to execute the detailed design of the STAR GLOBAL Interlock system.

The STAR Global interlock system is designed to allow the STAR detector system to operate safely; it provides protection against major equipment damage, particularly that due to the effects of fire and water leakage.

The STAR detector includes several detector components, including a Silicon Vertex Detector (SVT), a Time Projection Chamber (TPC), an Electromagnetic Calorimeter (EMC), a Forward TPC (FTPC), and a large magnet. Each of these has its particular safety hazards and precautions that must be recognized in the design of the global interlock system. Due regard must be taken to safeguard the operational integrity of these individual detector subsystems.

Physically, the detector components are mounted on the movable STAR detector, which can be situated either in the Wide Angle Hall or in the Assembly Hall. In addition, various support subsystems will be housed in the Control room, DAQ (data acquisition) room, Electronics Platforms, Assembly Hall, Wide Angle Hall and the Gas Mixing room.

Typically, each STAR detector component will have its own local interlock system that will detect and react to hazards localized to the particular component (over current or over temperature, for example). These local interlock systems are used to guide the power-up and power-down procedures, and will be covered in separate documents.

The STAR global interlock system is mainly concerned with major hazards, and contains interlock subsystems of the following:

- Fire Detection and Suppression
- Water Leak Detection
- Flammable Gas Detection
- Emergency-off equipment protection.

In the following sections, the implementation of these interlock subsystems in the various physical spaces is specified. The nature of the hazard detection equipment is specified and the expected responses to alarms generated by the detection equipment are given. These responses include automatic actions taken to reduce the hazard as well as annunciation of the alarms in various control rooms.

For convenience, the responses are summarized in Table 3.

### 1.1 Implementation.

Electrical interlocks shall be implemented using **for protection of equipment safety.** Relay logic, programmable logic controllers (PLCs) and other hardware logic may be used, but computer software or firmware (other than the PLCs) shall not be relied upon for the fail-safe operation of the safety system.

Computer programs, however, may be used for monitoring the status of interlock systems. Specifically, the EPICS-based software system that provides slow-control and monitoring for the STAR detector system can be used to distribute status information. However, it may not be made an integral part of the STAR global interlock system—i.e., it must not be able to affect the fail-safety property of the interlock system. The interlock system must remain fully functional even if the computer-based monitoring is not operational.

We have assumed the presence of the AGS Maincontrol room operators and EAG watch are available at all times that STAR is in operation or that its systems are active.

### 1.2 RHIC - STAR interlock interface.

A RHIC safety interlock system, separate from the STAR global interlock system, provides both personnel and equipment safety. Protection to STAR personnel and access control to the Wide Angle Hall, will be provided by RHIC and will be covered in the STAR operational readiness plan, which is under preparation. These aspects are beyond the scope of this document.

There will be certain interconnections between the STAR and RHIC interlock systems, which will be defined in the course of developing the two systems. Before the STAR detector can start up, it must receive ‘permission to operate’ from RHIC.

### 1.3 General Requirements

It is required that the interlock system satisfies the STAR Grounding Plan (CSN #202A). In particular, there shall be no conductive electrical connections to:

- The platform structure, the body of the STAR detector or the magnet steel;
- The DAQ or slow control systems.

Within each detector subsystem, conductive connections to racks and supporting structures are permitted.

## 2. FIRE DETECTION AND SUPPRESSION

Wherever possible the STAR detector uses non-flammable materials or materials that will not sustain a fire once the source of ignition has been removed. Materials of interest in this context include circuit board materials, cable insulation and non-metallic support structures.

In spite of the best efforts in this regard, fires are possible within the STAR detector electronics subsystems. Thus, one requirement of the STAR global interlock system is to minimize the effects of fires by including sensors of adequate sensitivity that detect the products of combustion promptly. In response to detection, the interlock systems shut down electrical power to the affected areas immediately, thereby removing the major source of ignition and, when appropriate, shut down sources of flammable gas.

It is a Department of Energy (DOE) requirement that fire suppression systems shall be used where possible and practicable when the value of equipment at risk exceeds the (DOE recommended) value of 250K$.

In the following, the fire detection and suppression requirements of the spaces and detector components of the STAR detector are discussed.

## 2.1 STAR system overview

### 2.1.1 Requirement

A fire detection system dedicated to STAR is required. Fire suppression systems will be used where appropriate.

### 2.1.1 Justification

The STAR detector is a multi-million dollar installation and, under DOE guidelines, must be protected from damage resulting from fire.

### 2.1.2 Design

Fire detection will be by Multi-Level Spot Smoke Detectors and High-Sensitivity Smoke Detectors.

Fire suppression will use sprinkler systems and Inergen suppression systems. The local control panel for the STAR detector fire system will be on the South platform. Fire alarms will be passed to the Brookhaven Fire Department via the building 1006 fire panel.

Audible alerts will inform personnel when an alarm has occurred. In most cases, monitoring of the status of the alarm system will be via relay logic or optical-coupled signals to prevent introducing ground loops, which could affect the quality of the signals from the STAR detector.

## 2.2 STAR Control room

### 2.2.1 Existing equipment

In the STAR control room, the existing RHIC safety system includes fire detection capability and a sprinkler system.

Shut down of AC power to this room in case of fire is by manual control—i.e., via a breaker panel in the room.

#### 2.2.2 Requirement

Since adequate fire detection and suppression already exist in the STAR control room, as part of the plant, no additional systems are required within the STAR global interlock system.

#### 2.2.3 Justification

Additional fire suppression for electronics equipment is not required since the value of the equipment housed in the control room does not exceed 250K$.

### 2.3 STAR DAQ room

The DAQ room has an existing sprinkler system, which is a permanent part of the building.

#### 2.3.1 Requirement

Both fire detection and suppression is required for the STAR electronics racks in Row DA in the DAQ room. Those racks in the DAQ room that are dedicated to the RHIC control system and to Slow Controls (Row DC) will have smoke detection but do not require fire suppression.

#### 2.3.2 Justification

The total value of equipment in each STAR double-rack subdivision in Row DA is in excess of 250K$. RHIC rack values and the other racks in Row DC are less than 250K$.

#### 2.3.3 Design

The electronics racks are grouped in rows and subdivided into double racks by side panels. A smoke detector will be of a type that allows multiple alarms depending of the amount of smoke; there is one alarm per rack row or double rack where the equipment protected is valued at more than 250K$. For those rack rows or double racks that contain 250K$ or more of equipment (row DA) a heat sensor is used to automatically trigger a fire suppression system. Experience has shown that this sensor is very reliable and provides a minimum number of false alarms. A heat sensor will be installed in all racks that have a fire suppression system.

##### 2.3.3.1 Fire detection

Each smoke alarm shall have at least two levels of alert. At minimum, there should be a *low-level* and *high-level* alert.

The low-level gives an early indication of a developing problem or provides an indication of a malfunction. An operational procedure will be developed to provide an adequate response to such an alarm. The locations of low-level alarms (i.e. which rack row) are annunciated as ‘warnings’ in the STAR control room.

A high-level alarm is a clear indication of smoke in that enclosed volume. These are annunciated as an ‘alarm’ in the STAR control room, the RHIC control room and the Fire Department.

#### 2.3.3.2 Response to a low-level alarm

An alarm from a low-level smoke detector is annunciated to the STAR control room.

A low-level signal may be a false alarm. In some cases, however, a low-level alarm may indicate an early warning of a developing fire.

#### 2.3.3.3 Response to a high-level alarm

The Fire Department responds.

The AC power to all racks in the rack row in which the alarm originated is turned off by a shunt-trip activated by the STAR global interlock system.

Building power and lights remain on.

#### 2.3.3.4 Response to a heat sensor alarm

An Inergen suppression system is used in Row DA of the DAQ room racks. In response to a heat sensor alarm in Row DA, Inergen automatically floods all racks in Row DA (N.B. automatic refers to the fact that action by the SGIS is not required for Inergen release).

The Fire Department responds.

AC power to the DAQ electronics (row DA) is turned off to remove sources of ignition. The AC power to all racks in the rack row in which the alarm originated is turned off by a shunt-trip activated by the SGIS.

Building power and lights remain on.

## 2.4 Electronics Platforms

The electronics platforms contain much of the supplemental electronics for the STAR detector including power supplies, timing circuitry, etc. There are three levels, two of which on the south platform have multiple rows of electronics racks. Each rack row is closed with front panels and rear doors, with cooling air circulating locally through heat exchangers connected to the cooling water system. Seals on the bottom of the racks isolate the interior of the racks from the steel sub-floor and cable tray system. Side panels provide smoke separation between rack subdivisions.

### 2.4.1 Requirement

A fire suppression system is required on the south platform for Level 1—Rack Row A (row 1A) only. Fire detection and an interlock trip of AC power is not sufficient protection for this row with expensive equipment.

### 2.4.2 Justification

Where possible racks are subdivided to keep the value of the contents to less than 250K$ per enclosed volume. There are, however, two double racks used in the trigger system where the value is greater than this amount. These racks are located on level 1, row A (row 1A). Therefore, a suppression system is required for this rack row. The existing sprinklers in the Assembly Hall and Wide Angle Hall are not effective for the multi-level platforms.

### 2.4.3 Design:

Detection and suppression is by rack rows and sub-sections of rack rows.

A multiple level smoke detector and heat sensor is used in each rack row to minimize false alarms and provide sufficient protection. The low-level alarm is annunciated to the STAR control room. A high-level alarm indicates a significant occurrence and appropriate action shall be taken. Dividers are used between racks to isolate hardware so that the maximum value is not exceeded. The dividers also provide smoke separation. If a given rack has fire suppression, a heat sensor is used to trigger the fire suppression system.

#### 2.4.3.1 Response to a low-level alarm

A low-level alarm from a smoke detector is annunciated to the STAR control room.

#### 2.4.3.2 Response to a high-level alarm

A high-level alarm results in the following actions:

- Shunt-trip of the rack row in which there was an alarm. Removing the AC power to racks removes the source of ignition.
- Annunciation of the alarm in the RHIC control room and the STAR control room. STAR control personnel respond appropriately.
- Annunciation of the alarm at the Fire Department. The Fire Department responds. This notification of the fire department does not require any action by the SGIS.
- Magnet power is ramped down. The ramp time is approximately two minutes. This is initiated by the SGIS by dropping the appropriate enable signal to the magnet power supply PLC system.
- Building power, lights and rack emergency lights remain energized.

#### 2.4.3.3 Response to a heat sensor alarm

A heat sensor alarm results in the following actions:

- The Inergen system dumps to the rack row in which the alarm originated (Inergen in South platform level 1, row A (row 1A) only).

- Shunt-trip of the rack row that had a heat sensor alarm . Removing the AC power to racks removes the source of ignition.

- Annunciation of the alarm in the RHIC control room and the STAR control room. STAR control personnel respond appropriately.

- Annunciation of the alarm at the Fire Department. This notification of the fire department does not require any action by the SGIS. The Fire Department responds.

- Magnet power is ramped down. The ramp time is approximately two minutes.

- Building power, lights and rack emergency lights remain energized.

## 2.5 STAR Detector

It is deemed impractical to install a fire suppression system inside the STAR detector. However, its construction materials are chosen to be non-combustible insofar as is practical. Thus, removal of sources of ignition will limit the spread of a fire.

### 2.5.1 Requirement.

A high-sensitivity smoke detector is used to detect the start of pre-combustion in the STAR detector. If smoke is detected, all power to the STAR detector is shut down. If the HSSD indicates that it has detected a malfunction, an alarm shall be sent to the STAR control room.

Detection of fire results in an AC power shunt-trip to all detector systems which supply power to the detector region, this excludes the DAQ system. The current in the STAR magnet will also be ramped down.

### 2.5.2 Justification

The construction of the STAR detector is accomplished with the use of non-flammable and non-fire-sustaining materials where possible. In addition, the main heat sources capable of causing fire in the detector are faults in the electrical system. By using materials that will not sustain a fire in the absence of a heat source, further damage to the STAR detector is limited once the AC power is removed.

This HSSD system is extremely sensitive. It has the capability of detecting smoldering circuit components before a fire actually starts. Given this sensitivity, and the good containment of the gas in the TPC vessel, there will be a ten minute delay before the TPC goes into purge mode. This purge of the TPC may be started earlier, or aborted, via an override mechanism.

### 2.5.3 Design:

The smoke detector installed in the detector will be a High Sensitivity Smoke Detector (HSSD). Conventional spot smoke detectors are not usable in the magnetic field and radiation environment of the STAR detector.

The High Sensitivity Smoke Detector is a high-reliability and self-checking system. Air is sampled from various parts of the STAR detector and analyzed for the presence of combustion and pre-combustion products. The STAR detector is divided into two zones, one at each end of the detector. Each zone is sampled at the top and bottom of the TPC wheel. The input from these two zones is combined to constitute one input to the HSSD system.

The HSSD can be programmed to provide detection at various levels. For start-up operation, low- and high-level alarms will be programmed. If intermediate warning levels are required or found useful, they will be added later.

The capability to shunt trip AC power at the AC breaker panels is provided for all power supplies feeding the detector.

#### 2.5.3.1East Zone and West Zone

The detector is sampled at sectors 11, 12, 1 & 2 and 5, 6, 7, & 8 (on one end), and 23, 24, 13 & 14 and 17, 18, 19, & 20 (on the other end), a total of four sampling regions (although input lines from all four regions are combined to constitute a single input to the HSSD).

#### 2.5.3.2Response to a low-level alarm or an HSSD system malfunction

Low-level alarms or HSSD system malfunctions will be annunciated to the STAR control room. The appropriate response to such an alarm will be taken by the watch personnel.

#### 2.5.3.3Response to a high-level alarm

In response to a high-level alarm, the following occurs:

- The alarm is annunciated at the STAR and RHIC control rooms.
- The alarm is annunciated at the Fire Department. The Fire Department will respond. This notification of the fire department does not require any action by the SGIS.
- The AC power for all systems feeding power to the STAR detector is shut down to remove all possible sources of ignition. This is accomplished by shunt tripping circuit breakers A11 and A12, which are located in panel A1 I the DAQ room. This turns off all external AC power to both platforms.
- The STAR magnet will be ramped down. This ramp down will take approximately two minutes.
- The TPC Gas system will go to purge mode automatically within ten minutes of receiving the high-level fire alarm. This purge may be instituted sooner, or aborted, via an override control.

### 2.6 Magnet System

#### 2.6.1 Requirement

Facility smoke detectors will provide smoke detection in the second floor equipment room which contains the STAR magnet power supplies.

#### 2.6.2 Justification

Smoke detection capability is necessary to provide equipment protection.

#### 2.6.3 Design

Spot smoke detectors will be located in the room where the magnet power supplies reside. *The connection of these smoke detectors to the Fire Department, and the interaction between these smoke detectors and the magnet power supplies is not done via the STAR global interlock system.*

## 3. WATER LEAK DETECTION

Water cooling is used for most of the electronics in the STAR detector. In spite of the best efforts to design, build, and install a reliable water cooling system, the possibility of leaks must be anticipated and protected against. Depending on the size of the leak, damage to powered electronics from a water leak can be expected if the power is not removed quickly.

The TPC and SVT Front end electronics systems use conventional water cooling systems. The SVT detector uses a leakless system, in which the cooling water circulates at less than atmospheric pressure to reduce the chance of water leaks.

A Tracetek leak detection system is planned.

### 3.1 STAR Control Room

There is no water-cooled electronic equipment in the control room.

### 3.2 STAR DAQ room

#### 3.2.1 Requirement.

Leak detection is required in the STAR DAQ electronics racks (row DA).

#### 3.2.2 Justification

This equipment uses circulating air for direct cooling. The circulating air is cooled in heat exchangers attached to the cooling water system.

#### 3.2.3 Design

One zone of a Tracetek system will be used in the DAQ room. It monitors for water leaks in rack row DA only.

#### 3.2.3.1 Response to faults

In response to detection of a water leak, the following actions occur:

1) Circulation of cooling water is shut down via solenoid valves. There is one solenoid valve on the water supply line to the DAQ room and one solenoid valve on the water return line from the DAQ room. In response to a water leak in the DAQ room, all of the modified chilled water to the DAQ room is shut off.

   To close the solenoid valves the SGIS shall supply power to the valves to actuate them. The power to the valve will be turned off when a readback signal from the valve indicates that it is in the closed position. If the SGIS does not receive this readback signal within 15 seconds of sending power to the valve, the power to the valve will be turned off and an alarm will be sent to the STAR control room.

2) The slow controls computer system is notified; it annunciates the alarm on the appropriate display.

3) AC power to rack row DA is immediately shut down.

#### 3.2.3.2 Response to Tracetek module malfunction

If a Tracetek module indicates that it has detected a malfunction, an alarm will be sent to the STAR control room. Some manner of indicating which module has indicated a fault should be presented on the SGIS panel view screen.

## 3.3 Electronics Platforms

### 3.3.1 Requirement

Leak detection is required in electronics racks.

### 3.3.2 Justification

Cooling water is used, via heat exchangers, to condition the recirculating air used to remove heat from the racks.

### 3.3.3 Design

Six zones of a Tracetek system will be dedicated to the Platform electronics racks, one zone/cable for each rack row on the South platform.

#### 3.3.3.1 Response to fault

In response to detection of a fault, the following actions occur:

1) Cooling water to the platform level containing the rack row with the leak is shut off via solenoid valves . There is one solenoid valve on the water supply line to each level of the platform and one solenoid valve on the water return line from each level of the platform. In response to a water leak, all of the modified

chilled water to the platform level containing the rack row with the leak is shut off.

To close the solenoid valves the SGIS shall supply power to the valves to actuate them. The power to the valve will be turned off when a readback signal from the valve indicates that it is in the closed position. If the SGIS does not receive this readback signal within 15 seconds of sending power to the valve, the power to the valve will be turned off and an alarm will be sent to the STAR control room.

2) The slow controls computer system is notified; it annunciates the alarm on the appropriate display.
3) AC power to all rack rows on the platform level indicating a water leak is shut down immediately. This is accomplished by shunt tripping the appropriate circuit breakers on the platform level.

#### 3.3.3.2 Response to Tracetek module malfunction

If a Tracetek module indicates that it has detected a malfunction, an alarm will be sent to the STAR control room. Some manner of indicating which module has indicated a fault should be presented on the SGIS panel view screen.

## 3.4 STAR Detector

### 3.4.1 Requirement

Leak detection and appropriate response is required in the STAR detector.

### 3.4.2 Justification

Cooling water is used for the TPC and SVT front-end electronics and the SVT Detector.

### 3.4.3 Design

Two zones of a Tracetek system will be dedicated to the STAR detector, one for each end.

One Tracetek cable will be routed to sectors 5, 6, 7 & 8 on the west TPC wheel and the SVT electronics (mounted on the TPC wheel). A second Tracetek cable will be routed to sectors 17, 18, 19, & 20 on the east TPC wheel and to the SVT electronics (mounted on TPC wheel).

#### 3.4.3.1 Response to a fault

In response to detection of a leak fault within the detector, the following actions occur:

1) The TPC HV Enable signal is dropped. In response to the loss of this signal the TPC interlock system will shutdown the FEE power to the detector, the cathode HV, the anode HV, and the gating grid system.

2) Magnet current is ramped down .

   Since risk to the magnet is not as high, a two minute ramp-down of magnet current is permitted.

3) Gas system power is not shutdown automatically and the gas system is not purged automatically.

4) An alarm is annunciated in the STAR control room.

#### 3.4.3.2 Response to Tracetek module malfunction

If a Tracetek module indicates that it has detected a malfunction, an alarm will be sent to the STAR control room. Some manner of indicating which module has indicated a fault should be presented on the SGIS panel view screen.

## 3.5 Magnet System

### 3.5.1 Requirement

Leak detection is required at the magnet power supplies and at the magnet itself.

### 3.5.2 Justification

Cooling water is used for the magnet power supplies, for the magnet power buses, and for the coils of the magnet.

### 3.5.3 Design

Water leak detection in the power supplies is by means of water mats internal to the supplies. These are interlocked to the local magnet power supply interlock chain.

Two zones of a Tracetek system will be dedicated to detection at the magnet. One zone will be comprised of a cable that runs under the supply side of the magnet water manifold and then under the West poletip manifolds (Tracetek 7). The second zone will be comprised of a cable that runs under the return side of the magnet water manifold and then under the East poletip manifolds (Tracetek 8).

The magnet water supply system has an internal leak detection system. The design of this internal leak system incorporates the fact that the magnet water system is a closed loop system, and hence, in the absence of leaks the volume of water in the system is a constant. There is a “make-up” water tank incorporated in the system that will supply water to the system in the event that the volume of water decreases. There are two levels of alarms that one may set, and monitor, with this system. The first level of alarm is when the system has lost some selectable volume of water (e.g. 100 gallons) within a selectable period of time (e.g. ten minutes). The second level of alarm is when the system has lost a selectable volume of water (e.g. 150 gallons) within a selectable period of time (e.g. ten minutes), at which point the system shuts itself down. There is one additional diagnostic signal from this system. When the volume of water in the makeup tank has decreased by a selectable amount, a pump starts refilling the make-up tank at the rate of five gallons per minute. A signal can be monitored that indicates when this pump is in operation.

In the following, distinction is made between a “normal” fault (a slow water leak) and a major fault such as a blown cooling-water hose. A major fault is defined as a water system fault that is detected by the internal water system monitoring system that is described above. A normal fault is defined as a leak that is detected by the Tracetek systems for the magnet.

#### 3.5.3.1 Response to a “normal” fault at the magnet power supplies

The response to detection of a leak fault at the magnet power supplies is handled by the **magnet subsystem PLC based interlock system, not by the SGIS**. The following actions occur:

1) The magnet power supply cooling water is shut down. This is done to minimize the quantity of water leaked.

2) The slow controls system is notified.

3) Magnet current is ramped down.

   Since risk to the magnet is not as high, a two-minute ramp-down of the magnet current is permitted. A two-minute delay is long enough to allow an orderly shutdown via subsystem interlocks and slow controls, but is short enough to prevent damage to the hardware.

#### 3.5.3.2 Response to “normal" water leaks at the magnet

Normal water leaks detected at the magnet result in an alarm being annunciated in the STAR control room, and a notification being sent to the STAR Slow Controls system. The action to be taken by the shift personnel shall be determined and incorporated into their training and perhaps incorporated into a procedures document.

Gas system power is not shutdown automatically and the gas system is not purged automatically.

#### 3.5.3.3 Response to “major” water leaks

In response to detection of a large water leak fault, equivalent to a blown cooling water hose, the following actions occur:

1) Magnet DC current is shut down without delay. **This action is taken via a signal passing between the water system interlock system and the magnet interlock system, not by the SGIS.**

2) The Magnet (coils) water system is shut down without delay. **This action is taken by the water system PLC based interlock system, not by the SGIS.**

# 4. FLAMMABLE GAS DETECTION

The present plans for the physical construction of detector assemblies in the STAR detector include the use of the following types of gases.

- The TPC will use P10—which is composed of 10% methane and 90% argon—in its active volume.
- The TPC will use nitrogen as an insulating gas surrounding the TPC.
- The FTPC will use 50% carbon dioxide, 50% argon.
- The EMC will use 50% carbon dioxide, 50% argon.

Of these gases, only P10 presents a possible fire hazard. When mixed with an appropriate proportion of oxygen, P10 burns very slowly; at other proportions, it is not flammable. P10 is considered a flammable gas at BNL.

The STAR gas detection system is for equipment safety. RHIC will provide a system for personnel safety.

A RHIC Flammable gas detection system is planned for the Wide Angle Hall (WAH). WAH exhaust fans are included as well. A gas detection system is required for the Assembly Hall since P10 will be used therein. This document will not describe the detailed design of the RHIC detection system.

### 4.1.1 Requirement

A gas detection system is required.

### 4.1.2 Justification

The presence of a gas, that can ignite, results in the requirement that a flammable gas detection system is needed.

### 4.1.3 Design

An air sampling system is to be provided. In response to a gas alarm, typically the system where gas was detected will be shut down and the gas system purged.

## 4.2 STAR Control Room

Flammable gas detection is not needed in the STAR control room, since no gas equipment is in that room.

## 4.3 STAR DAQ room

Flammable gas detection is not needed in the STAR DAQ room, since no gas equipment is in that room.

## 4.4 Electronics Platforms

The platforms are a central area where the gas detection system will be mounted, but detection capability is not required in this area.

## 4.5 STAR Detector

A flammable gas detection system is required because of the use of flammable gas components in the TPC.

### 4.5.1 Requirement

A flammable gas detection system is required. When the detector is in the Assembly Hall, fans may be required to provide air circulation around the detector.

### 4.5.2 Justification

The possibility of a leak from the TPC gas system results in the requirement for flammable gas detection.

### 4.5.3 Design

An air sampling system will monitor the interior of the STAR detector to detect trace amounts of flammable gas.

It will have two zones of operation: the East and West wheels of the TPC. Each zone is sampled at sectors

- 11, 12, 1 & 2 (west side—top),
- 5, 6, 7 & 8 (west side—bottom),
- 23, 24, 13 & 14 (east side—top), and
- 17, 18, 19 & 20 (east side—bottom)

- a total of four sampling areas. These four samples are combined to constitute the single input to the gas detection system.

Three levels of alarms are possible—low, mid and high.

#### 4.5.3.1 Response to low-level alarm or a system malfunction

In the event of a low-level alarm, the following actions are taken:

1) The STAR control room is notified.
2) The slow controls system is notified.

#### 4.5.3.2 Response to mid-level alarm

The mid-level alarm will be implemented at a later date if needed.

#### 4.5.3.3 Response to high-level alarm

In the event of a high-level alarm, the following actions are taken:

1) The STAR control room is notified.

2) The RHIC control room is notified.

3) The fire department is notified and then it responds.

4) The slow controls system is notified.

5) The TPC gas system is sent to purge mode. This is accomplished by dropping the appropriate enable signal to the TPC PLC system.

6) All power to the North and South electronics platforms is shut down without delay. This removes power from all of the detector mounted electronics and high voltage systems.

7) The magnet power is ramped down.

### 4.6 Magnet System

Flammable gas detection is not needed in the magnet system, since it uses no gas.

## 5. POWER EMERGENCY-OFF SYSTEM

**This section discusses a possible future implementation of a system of Emergency off buttons. These emergency off buttons are not necessary for the first year implementation of the Star Global Interlock System.**

The power Emergency-off system is intended for the emergency use of personnel who detect hazardous conditions that require immediate action. Clearly labeled manually operated Power emergency-off buttons are to be located at strategic locations in the STAR area.

The STAR power emergency-off system is interlocked to the AC power distribution system and via shunt-trips can force circuit breakers to open, thereby positively removing electrical hazards, and if deemed necessary, provide purging of the TPC gas system.

In the Wide Angle Hall, the power emergency-off buttons associated with the STAR safety interlock system shall be clearly labeled to be easily distinguishable from the emergency-off buttons/if any, associated with the RHIC PASS interlock system.

### 5.1 STAR Control Room

Two power emergency-off buttons are to be installed in the STAR control room.

The first of these Emergency-off buttons, which will be referred to as the STAR Global Emergency Off, is a last resort backup to all other STAR safety systems. Operation of this button results in a complete shutdown of the STAR detector and all associated equipment, including the magnet power and water, and the power to the TPC gas mixing room.

The second of these emergency-off buttons shuts down all power to the detector platforms and the detector itself.

#### 5.1.1 Requirement

Power emergency-off shall be available in the STAR control room.

The buttons shall be double-action switches to prevent accidental operation. Double-action switches are designed to require two different physical actions—such as push, then pull—to actuate the switch.

### 5.1.2 Justification

The purpose is to provide hardware protection in emergencies where immediate action is imperative. The use of the emergency-off button that removes all power from all STAR systems is a last resort panic button.

### 5.1.3 Design

The use one of the STAR Global emergency-off button in the STAR control room will shut down the entire STAR experiment. This requires shunt tripping of all AC power to all parts of the STAR detector system, and a gas system purge. To insure that this happens, it may be necessary to supply AC power through multiple breakers—i.e., to supply each circuit via two or more breakers wired in series and located in separate panels.

The use of the other emergency-off button in the STAR control room will shut down all power to the electronics platforms and to the detector itself.

## 5.2 STAR DAQ room

### 5.2.1 Requirement

There is no requirement for an emergency-off button in the DAQ room. Local circuit breaker panels are sufficient protection against electrical hazards in this room.

Circuit breakers for electronics racks must be located in the DAQ room and readily accessible.

## 5.3 Electronics Platforms

### 5.3.1 Requirement

A power emergency-off button is required on each level of the North and South platforms. Power emergency-off buttons shall be located near stairways or exits on each level.

### 5.3.2 Justification

The emergency-off buttons are needed to provide hardware protection in case of safety interlock system malfunction, or if personnel in the area notice an electrical system malfunction.

### 5.3.3 Design

Operation of an emergency-off button on the Electronics Platforms results in the following:

1) All AC power to the platforms is shut down immediately.
2) The DC current to the magnet is shut down immediately.
3) The action is annunciated in the control room.

## 5.4 STAR Detector

### 5.4.1 Requirement

At least two emergency-off buttons are to be located around the perimeter of the detector.

### 5.4.2 Justification

The emergency-off buttons are needed to provide hardware protection in the event of safety interlock system malfunction, or if personnel in the area notice an electrical system malfunction.

### 5.4.3 Design

Operation of any emergency-off button in the detector area results in the following:

1) All AC power to the platforms is shut down immediately.
2) DC current to the magnet is shut down immediately.

## 5.5 Magnet System

### 5.5.1 Requirement

An adequate number of emergency-off buttons near power supplies is required. In addition, an emergency-off button shall be installed just inside the door to the room that contains the magnet power supplies.

### 5.5.2 Justification

The emergency-off buttons are needed to provide hardware protection in the event of a safety interlock system malfunction.

### 5.5.3 Design

Activation of a magnet emergency-off button immediately shuts down AC power to the magnet power supplies via removal of the STAR “enable operation” permissive signal to the local magnet power supply interlock chain. The magnet current decays through a free-wheeling diode.

### 5.6 Gas Mixing Room

The safety interlocking within the gas mixing room is under the purview of the RHIC safety systems and is therefore not detailed by this document.

# 6. RHIC SYSTEMS

## 6.1 Fire Detection

### 6.1.1 Gas Mixing room

Fire detection and suppression in the gas mixing room is the responsibility of the RHIC safety systems. Removal of AC power starts an automatic purge of the gas system and removes sources of ignition. The room also has a sprinkler system.

Some additional recommendations follow. (Also, see documentation regarding the TPC gas system and the subsequent reviews.)

#### 6.1.1.1 Recommendation

Spot fire detection interlocked to AC power is recommended.

#### 6.1.1.2 Justification

Methane will be mixed with Argon in this room to form the gas mixture P10. The possibility of escaping methane represents a fire hazard.

#### 6.1.1.3 Design

Multiple level smoke detectors in each protected location are recommended to minimize false alarms. The dollar value of the hardware protected by smoke detectors is less than 250K$.

#### 6.1.1.4 Response to low-level alarm

A low-level alarm from a single smoke detector may be a false alarm or it may be an early warning of a developing fire. All low-level alarms are annunciated to the STAR control room.

#### 6.1.1.5 Response to high-level alarm

A high level alarm from a smoke detector results in the following actions:

1) It results in a shunt-trip of all AC power to the gas mixing room except for building power, lights and emergency lighting. (All lights in the area will be in explosion-proof enclosures.) Removing the AC power removes sources of ignition and allows safe access for Fire Department personnel.

2) The alarm is annunciated in the RHIC control room and the STAR control room.

3) The alarm is annunciated to the Fire Department. The Fire Department responds.

### 6.1.2 RHIC facilities

A High-Sensitivity Smoke Detector (HSSD) currently exists in the Assembly Hall and a similar system is scheduled to be installed in the Wide Angle Hall. At present, this detector system is not covered by this document—a connection to the STAR safety interlock system may be defined in the future.

Fire Alarm pull stations and portable fire extinguishers currently exist near exits to the area and other prominent locations. The STAR detector does not shutdown automatically if a fire alarm is pulled.

## 6.2 Flammable gas Detection

### 6.2.1 RHIC Facilities

#### 6.2.1.1 Recommendation

A system to detect flammable gas in the Wide Angle Hall and the Assembly Hall is required.

#### 6.2.1.2 Justification

There is potentially flammable gas in the Wide Angle Hall because of the gas used in the TPC.

#### 6.2.1.3 Design

1) In the event of the detection of flammable gas within the room, the following actions should be taken:

2) The remote AC breaker for the gas system is shunt-tripped. This results in an automatic purge of the gas system.

3) The remote AC breaker for the STAR electronics (breaker A11, located in A1 panel) is shunt-tripped to reduce spark hazard.

4) The event is annunciated to the STAR control room, the RHIC control room and the Fire Department.

5) Exhaust fans are activated.

6) Building AC power and lights remain on.

7) The magnet power is ramped down.

### 6.2.2 Gas Mixing Room

This system is not detailed in this document. RHIC systems cover this area. STAR recommends as follows:

#### 6.2.2.1 Recommendation

A flammable gas detection system is required.

#### 6.2.2.2 Justification

Methane is mixed with argon in this room to supply the TPC.

#### 6.2.2.3 Design

In the event of the detection of flammable gas within the room, the following actions should be taken:

1) The remote AC breaker for the gas system is shunt-tripped. This results in an automatic purge of the gas system
2) The event is annunciated to the STAR control room, the RHIC control room and to the Fire Department using intrinsically safe wiring. Intrinsically safe wiring is such that any sparks due to shorts, etc., are of insufficient energy to cause ignition of flammable gases.
3) The STAR slow controls computer system is notified.
4) Building AC power and lights remain on.

## 6.3 Emergency Power off buttons

RHIC (PASS system) emergency-off buttons in the Wide-angle Hall and tunnel areas are primarily intended as a radiation safety system.

The safety interlocking within the RHIC facilities is under the purview of the RHIC safety systems and is therefore not detailed by this document. However, the following recommendations are made.

### 6.3.1 Recommendation

Means to initiate a emergency-off for access control violation is recommended.

### 6.3.2 Justification

The emergency-off button is needed to provide personnel protection in the event of safety procedure violation or an interlock system malfunction.

### 6.3.3 Design

Activation of a RHIC emergency-off button in the Wide Angle hall, the Assembly Hall or the Magnet Power Supply room should be annunciated as an alarm to the STAR control room as well as to the RHIC control room.

## 6.4 Leak Detection

### 6.4.1 Gas Mixing Room

There are no requirements for water leak detection in the Gas Mixing room, since water leaks are not a potential hazard to the installed equipment in this room.

### 6.4.2 RHIC Facilities

There are no requirements for water leak detection in the STAR Global Interlock System to cover RHIC facilities.

# 7. FAIL SAFE CONSIDERATIONS FOR SGIS

## 7.1 Enable Signals

The SGIS sends two enable signals to the TPC subsystem SLC based interlock system, and two enable signals to the magnet subsystem PLC based interlock system (please see Table 2). The SGIS will be designed such that any unintended loss of the SGIS system will result in the removal of these four enable signals. The removal of these enable signals will cause the DC current in the magnet to be dropped immediately, the TPC High Voltage systems to shut down, and the TPC gas system to go immediately to purge mode.

## 7.2 Shunt Trip Circuit Breakers

The SGIS will also be designed such that any unintended loss of the SGIS system will result in the shunt trip of the circuit breakers A11 and A12 in the A1 circuit breaker panel (please see Table 2). The tripping of these two circuit breakers (A11 and A12) removes all power from the STAR Detector based systems (i.e. it removes both the clean and dirty 480V power feeds to the STAR Detector).

All other shunt trip equipped circuit breakers in the STAR power distribution system will not be tripped if the SGIS encounters an unintended loss.

# 8. SGIS BYPASS SYSTEM

## 8.1 Introduction

The design of the SGIS must include the ability to “Bypass” some of the input signals to the SGIS, as well as some of the signals out of the SGIS.

As used here, a bypass of an input signal signifies some way to generate a signal that the SGIS expects or requires to be present during normal operations. The primary reason that one requires this input bypass capability is to allow for the maintenance of devices that input signals to the SGIS, while maintaining all other capabilities of the SGIS system. An example of such a signal is one that is normally present from each of the numerous *Tracetek* leak detector units. In normal operation, the SGIS receives a positive signal back (e.g. 24V) from each of the *Tracetek* units. The loss of one of these return signals indicates the detection of a water leak, and the SGIS takes some mitigating actions (.e.g. stop flow of particular water path and shut off particular power distribution). The ability to generate an input bypass signal allows one to swap out a Tracetek unit for maintenance without bringing down other STAR systems.

An output signal bypass allows one to operate a subsystem of the STAR detector that requires an input (also known as "enable") signal from the SGIS to operate. An example of such an output signal is the TPC High Voltage system enable signal. The TPC subsystem SLC based interlock system requires an input enable signal from SGIS to send HV out to the TPC. One requires the ability to generate this output bypass signal for instances where the SGIS is offline for maintenance during a period when one needs to operate the TPC systems for testing.

It is recognized that various parties will need to receive notification whenever a bypass system is in use with the SGIS. Discussions on this topic are presently ongoing.

## 8.2 Input Bypasses

Listed below are the input signals to the SGIS for which the ability to generate a bypass signal is necessary:

- High Level Fire Alarm from DAQ
- High Level Fire Alarm from Platform
- High Level Fire Alarm from the Detector
- High Level Gas Alarm from the Detector
- ALL Tracetek leak detection units

## 8.3 Output Bypasses

Listed below are the output signals from the SGIS for which the ability to generate a bypass signal is necessary:

- A11 shunt trip circuit breaker
- A12 shunt trip circuit breaker
- TPC AC Enable for Gas rack 2 (gas enable)
- TPC HV enable
- Magnet Fast Off enable
- Magnet Slow shut off enable

# 9. LOGIC STATES OF THE SGIS

## 9.1 Introduction

This section defines the four logic states that the STAR Global Interlock System (SGIS) can be in, and discusses the present plan for making transitions between these four states. These four states are defined as the STANDBY STATE, the RUNNING STATE, the FAULT STATE, and the OFFLINE STATE.

## 9.1.1 Definition of Logic States for SGIS

### 9.1.1.1 STANDBY STATE

The general goal of the STANDBY STATE is to allow one to bring the various components of the STAR detector system into an operational mode and to verify that all of the expected input signals to the SGIS are present. This state of the system is defined by the set of statements below:

1. The SGIS PLCs shall be operating in a mode such that one can verify at the PLC terminal screen the status of all input signals to the SGIS. As an example of this utility, one should be able to bring up a screen and check that each of the TRACETEK detectors is sending/returning a signal signifying whether they are in a fault state or not. A possible implementation of this could be colored, labeled buttons for each of the input signals, red indicating fault or lack of the input signal, and green indicating that the signal is present and in a no-fault state.
2. All of the AC circuit breakers that have the shunt trip capability should be set such that they are on, or can be turned on. Thus all signals that prevent energizing the shunt trip circuit breakers should not be present. This does not mean that the SGIS turns these circuit breakers on (it is the author's understanding that this capability to switch the circuit breaker from off to on is not in the present system). In the STANDBY state the SGIS should just allow one to energize any or all of the shunt trip circuit breakers which are within its control.
3. The SGIS signals that deal with the solenoid water valves under the control of the SGIS system (two valves for each level of the South platform and two valves for the DAQ room) should be in a state that all of the valves can be open. This does not mean that the SGIS opens any valves that it detects to be closed.
4. Both of the Enable signals to the TPC interlock system shall be in the "OFF" state. OFF means that the SGIS is not giving permission to the TPC to generate HV on its Cathode, anodes, or gating grids, and that the TPC gas system is not receiving permission to be in any state other than off or purge mode.
5. Both of the Enable signals to the magnet shall be in the "OFF" state. OFF means that the SGIS is not giving the magnet permission to be in any state that circulates current in any of the STAR magnet coils.
6. In the STANBY state, any available input signal bypasses shall be capable of being in use.
7. There is no time limit for how long the SGIS can remain in the STANDBY STATE.

#### 9.1.1.2RUNNING STATE

When the SGIS is in the RUNNING STATE all necessary input signals to the SGIS are present, the SGIS is monitoring all of these input signals, and the SGIS is able to take the prescribed actions (specified in SGIS Requirements Document) if any fault signal is detected. In the RUNNING STATE there are no detected fault signals present. This state of the system is defined by the set of statements below:

1. All input signals are present, and all input signals indicate that they are not in a fault status. As defined here, an input bypass signal is equivalent to an input signal from any sensing device or detector.
2. In the RUNNING STATE the SGIS is actively monitoring all input signals and is capable of taking any and all of the actions in response to fault signals that are specified in the SGIS requirements document.
3. The TPC enable signals may be present or absent in the RUNNING STATE. Their presence or absence in no way defines the RUNNING STATE.
4. The TPC Status signal, which is an input to the SGIS, is never defined to be in fault status. It merely indicates that the TPC system is fully enabled or is not fully enabled.
5. The magnet enable signals may be present or absent in the RUNNING STATE. Their presence or absence in no way defines the RUNNING STATE.
6. The magnet Status signal, which is an input to the SGIS, is never defined to be in fault status. It merely indicates that the magnet system is fully enabled or is not fully enabled.

#### 9.1.1.3FAULT STATE

The FAULT STATE is defined as the state of the SGIS when it is actively monitoring all of the input signals, is fully capable of taking what ever actions are prescribed in the SGIS requirements document, and one or more of the input signals is indicating a fault. In this state the system continues monitoring all input signals and remains capable of taking any of its prescribed actions. This state of the system is defined by the set of statements below:

1. The SGIS is actively monitoring all of its input signals.
2. The SGIS is capable of taking any of the actions that are prescribed in the SGIS requirements document.
3. One or more of the input signals to the SGIS is indicating a fault.
4. Any signal which indicated a fault shall be latched in the fault state.

#### 9.1.1.4OFF LINE STATE

In the OFF LINE STATE the SGIS system is not functional. In this state the input signals may or may not be present, may or may not be monitored, and the SGIS may not be counted on to take any of the prescribed actions in response to input fault signals. The

OFF LINE STATE may come about because the PLC system has been removed, powered down, or in any other fashion placed in a non-operative status. This state of the system is defined by the set of statements below:

1. The SGIS hardware may or may not be physically present.
2. The SGIS hardware may or may not be powered.
3. The SGIS may or may not be able to detect input signals.
4. The SGIS may not be counted on to take any of the prescribed actions in response to a fault detailed in the SGIS requirements document.

### 9.1.2 Making Transitions between SGIS Logic States

In this section the methods by which the Logic State of the SGIS is changed are discussed, and to the point that is feasible, defined.

#### 9.1.2.1 Allowed Transitions

There are a limited number of transitions allowed for the SGIS. These allowed transitions are:

1. OFF LINE STATE to STANDBY STATE
2. STANDBY STATE to OFF LINE STATE
3. STANDBY STATE to RUNNING STATE
4. RUNNING STATE to STANDBY STATE
5. RUNNING STATE to FAULT STATE
6. FAULT STATE to STANDBY STATE
7. FAULT STATE to RUNNING STATE
8. RUNNING STATE to OFF LINE STATE
9. FAULT STATE to OFF LINE STATE

The transitions numbered 8 and 9 in the above list are merely included for completeness. They are listed to indicate that it will be possible, through some catastrophic event, for the SGIS to become inoperable. Neither of these transitions will be used in the course of normal operations, and the ability to make these transitions shall not be designed into the SGIS.

To ensure proper authorization before some of the transitions below can be initiated there will be authorization codes used in the SGIS. At the present time it is envisioned that there will be two authorization levels for these codes. Further discussion of these codes may be found in the next section of this document.

1.) OFF LINE STATE to STANDBY STATE

This document will not deal with the physical installation of the SGIS system. In this description it is assumed that the SGIS has been installed, wired up, and connected to

AC power. There is no adverse safety effect or concern in making this transition. As such no designed authorization feature is envisioned to allow this transition of the system. The author imagines that this transition could be accomplished by pushing one of the terminal screen buttons on the SGIS, but the SGIS designer is free to implement the method to initiate this transition by any reasonable means.

2.) STANDBY STATE to OFF LINE STATE

In the STANDBY STATE the SGIS is not being relied upon to maintain the STAR detector system in a safe state. As such, there is no adverse safety effect or concern in making this transition, and no designed authorization feature is envisioned to allow this transition of the system. The author imagines that this transition could be accomplished by pushing one of the terminal screen buttons on the SGIS, but the SGIS designer is free to implement the method to initiate this transition by any reasonable means.

3.) STANDBY STATE to RUNNING STATE

To make the transition into the RUNNING STATE all of the input signals must be present at the SGIS (whether from a device, a detector, or an input bypass system), and in addition, none of these input signals can indicate a fault. For clarity on this last criteria, one of the input signals from a remote sensor (e.g. a Tracetek module) could be indicating a fault, but a software bypass signal would have to be utilized for this signal so that it appears to the PLC logic that there are no faults. A responsible and authorized person must initiate this transition. Therefore, it will be required that a code be entered at the terminal screen to initiate this transition. The authorization level of the code necessary to make this transition shall be level one. The code shall be unique, and assigned to a particular authorized individual. The action in addition to entering a valid code (e.g. pushing a button, etc.) for initiating this transition is left to the SGIS designer.

4.) RUNNING STATE to STANDBY STATE

In making this transition the equipment protection provided by the SGIS is being removed. As such this transition shall require an authorized individual to enter their unique code into the SGIS via the terminal screen. The authorization level of the code used to make this transition shall be level two. The action in addition to entering a valid code (e.g. pushing a button, etc.) for initiating this transition is left to the SGIS designer.

5.) RUNNING STATE to FAULT STATE

This transition is one that is initiated by the SGIS system itself. No human action is required for this transition to occur.

6.) FAULT STATE to STANDBY STATE

In making this transition the equipment protection provided by the SGIS is being removed. In addition any action or actions taken by the SGIS to deal with the fault may be changed or invalidated once the transition has taken place. As such this transition shall require an authorized individual to enter their unique code into the SGIS via the terminal screen. The authorization level of the code used to make this transition shall be level two. The action in addition to entering a valid code (e.g. pushing a button, etc.) for initiating this transition is left to the SGIS designer.

7.) FAULT STATE to RUNNING STATE

To make this transition whatever fault signal initiated the transition into the FAULT STATE must be cleared. The reader is reminded that all faults are latched. To clear a fault from the SGIS one will be required to enter their unique code, which has the appropriate or higher authorization level, and to push the button on the screen that indicates the fault. The authorization level of the code required to clear any fault used in the SGIS shall be clearly defined.

# 10. AUTHORIZATION CODES

## 10.1 Introduction

As defined in the previous section of this document, the SGIS shall have the feature that certain actions will require the individual taking the action to enter a unique code. These codes shall be referred to as authorization codes, as their function is to provide a degree of ensurance that the individual taking the action is properly authorized. The requirements to be assigned a security code, and the level of authorization of the code assigned, will be defined elsewhere. Among other criteria there will certainly be training requirements.

The codes may either be unique, and assigned to one and only one individual, or a particular code may be assigned to a number of individuals.

It shall be possible to remove a given codes acceptance by the SGIS. This capability will enable individuals authorization to manipulate the SGIS to be removed for such things as lapses in required training, or other reasons.

At the present time it is envisaged that there will be only two levels of authorization codes. These levels will be referred to as level one and level two. Level two is the higher of the two authorization levels, and as such will require more expertise and perhaps training than that necessary for level one.

The Authorization levels required to initiate the various actions of the SGIS system are defined in Table 1.

Table 1. Authorization Level Requirements to Initiate SGIS Actions

| SGIS Action | Authorization level | Comments |
|---|---|---|
| STANDBY to RUNNING | 2 | |
| RUNNING to STANDBY | 2 | |
| Clear rack water leak fault | 1 | |
| Clear low level smoke alarm | 1 | |
| Clear high level smoke alarm | 2 | |
| Clear high level gas detection alarm | 2 | |
| Clear Detector water leak alarm | 2 | |
| Place Detector Gas or smoke detection systems in Bypass mode | 2 | |
| Others to be determined. | | |

*Note. This table is included at this time merely as an example. A full table will be developed.*

## 11. INPUT AND OUTPUT SIGNALS FOR THE STAR GLOBAL INTERLOCK SYSTEM

### 11.1 Table 2. List of Input signals to the STAR Global Interlock System

| STAR SYSTEM | Signal | Type of Signal | Source for Signal | Comments |
|---|---|---|---|---|
| TPC Gas System | Status: 1=on, 0=off | 24 VDC | SLC Ground | |
| | Spare | 24 VDC | SLC Ground | |
| | Spare | 24 VDC | SLC Ground | |
| | Spare | 24 VDC | SLC Ground | |
| Magnet System | Status: 1=on, 0=off | 24 VDC | Dry Contact | |
| | Spare | 24 VDC | Dry Contact | |
| | Spare | 24 VDC | Dry Contact | |
| | Spare | 24 VDC | Dry Contact | |
| Heat & Smoke Detection<br>PLATFORM | High Level Smoke Alarm (HLSA) Row 1A | 24 VDC | Dry Contact | |
| | HLSA Row 1B | 24 VDC | Dry Contact | |
| | HLSA Row 1C | 24 VDC | Dry Contact | |
| | HLSA Row 2A | 24 VDC | Dry Contact | |
| | HLSA Row 2B | 24 VDC | Dry Contact | |
| | HLSA Row 2C | 24 VDC | Dry Contact | |
| | Low Level Smoke Alarm (LLSA) Row 1A | 24 VDC | Dry Contact | |
| | LLSA Row 1B | 24 VDC | Dry Contact | |
| | LLSA Row 1C | 24 VDC | Dry Contact | |
| | LLSA Row 2A | 24 VDC | Dry Contact | |
| | LLSA Row 2B | 24 VDC | Dry Contact | |
| | LLSA Row 2C | 24 VDC | Dry Contact | |
| | Spare | 24 VDC | Dry Contact | |
| | Spare | 24 VDC | Dry Contact | |
| | Spare | 24 VDC | Dry Contact | |
| | Spare | 24 VDC | Dry Contact | |
| | Spare | 24 VDC | Dry Contact | |
| | 1 = Heat Sensor Alarm | 24 VDC | Dry Contact | |
| Smoke Detection<br>DAQ Room | 1 = High Level Smoke Alarm (HLSA) Row DA | 24 VDC | Dry Contact | Rack Row DA |
| | 1= HLSA Row DC | 24 VDC | Dry Contact | Rack Row DC |
| | 1 = Low Level Smoke Alarm (LLSA) Row DA | 24 VDC | Dry Contact | Rack Row DA |
| | 1 = LLSA Row DC | 24 VDC | Dry Contact | Rack Row DC |
| | 1 = HLSA Floor | 24 VDC | Dry Contact | Floor |
| | 1 = LLSA Floor | 24 VDC | Dry Contact | Floor |
| | Spare/upgrade | 24 VDC | Dry Contact | Rack Row DB |
| | Spare/upgrade | 24 VDC | Dry Contact | Rack Row DB |
| HSSD on Detector | 1=High level HSSD Alarm | 24 VDC | Dry Contact | Signals will be picked up from a panel in the Counting house utility room. |
| | 1=Low level HSSD Alarm | 24 VDC | Dry Contact | |

| | | | | |
|---|---|---|---|---|
| | Malfunction 1=OK | 24 VDC | Dry Contact | |
| | Spare | 24 VDC | Dry Contact | |

**Table 2. List of Input signals to the STAR Global Interlock System (Continued)**

| STAR SYSTEM | Signal | Type of Signal | Source for Signal | Comments |
|---|---|---|---|---|
| Gas Detection on Detector | High level Gas Alarm | 24 VDC | Dry Contact | |
| | Low level Gas Alarm | 24 VDC | Dry Contact | |
| | Malfuntion 1 = OK | 24 VDC | Dry Contact | |
| | Spare | 24 VDC | Dry Contact | |
| Water Detection PLATFORMS | 1 = Water leak 1 | 24 VDC | Dry Contact | Rack Row 1A |
| | 1 = Tracetek 1 OK | 24 VDC | Dry Contact | Rack Row 1A |
| | 1 = Water leak 2 | 24 VDC | Dry Contact | Rack Row 1B |
| | 1 = Tracetek 2 OK | 24 VDC | Dry Contact | Rack Row 1B |
| | 1 = Water leak 3 | 24 VDC | Dry Contact | Rack Row 1C |
| | 1 = Tracetek 3 OK | 24 VDC | Dry Contact | Rack Row 1C |
| | 1 = Water leak 4 | 24 VDC | Dry Contact | Rack Row 2A |
| | 1 = Tracetek 4 OK | 24 VDC | Dry Contact | Rack Row 2A |
| | 1 = Water leak 5 | 24 VDC | Dry Contact | Rack Row 2B |
| | 1 = Tracetek 5 OK | 24 VDC | Dry Contact | Rack Row 2B |
| | 1 = Water leak 6 | 24 VDC | Dry Contact | Rack Row 2C |
| | 1 = Tracetek 6 OK | 24 VDC | Dry Contact | Rack Row 2C |
| | 1 = Water leak 7 | 24 VDC | Dry Contact | North man. + W. P.T. |
| | 1 = Tracetek 7 OK | 24 VDC | Dry Contact | North man. + W. P.T. |
| | 1 = Water leak 8 | 24 VDC | Dry Contact | South man. + E. P.T. |
| | 1 = Tracetek 8 OK | 24 VDC | Dry Contact | South man. + E. P.T. |
| | 1 = Water leak 9 | 24 VDC | Dry Contact | West TPC Wheel + SVT supply manifold |
| | 1 = Tracetek 9 OK | 24 VDC | Dry Contact | West TPC Wheel + SVT supply manifold |
| | 1 = Water leak 10 | 24 VDC | Dry Contact | East TPC Wheel + SVT return manifold |
| | 1 = Tracetek 10 OK | 24 VDC | Dry Contact | East TPC Wheel + SVT return manifold |
| Water Detection DAQ Room | 1 = Water leak 11 | 24 VDC | Dry Contact | Rack Row DA |
| | Spare/Upgrade | 24 VDC | Dry Contact | Rack Row DC |
| | Spare/Upgrade | 24 VDC | Dry Contact | Rack Row DB |
| | Spare | 24 VDC | Dry Contact | |
| | Spare | 24 VDC | Dry Contact | |
| | Spare | 24 VDC | Dry Contact | |
| Confirmation from Solenoid Valves | 1 = DAQ supply valve closed | 24 VDC | Dry Contact | DAQ Room |
| | 1 = DAQ return valve closed | 24 VDC | Dry Contact | DAQ Room |
| | 1 = P1 supply valve closed | 24 VDC | Dry Contact | Platform level 1 |
| | 1 = P1 return valve closed | 24 VDC | Dry Contact | Platform level 1 |
| | 1 = P2 supply valve closed | 24 VDC | Dry Contact | Platform level 2 |
| | 1 = P2 return valve closed | 24 VDC | Dry Contact | Platform level 2 |
| Confirmation of AC Circuit Breaker Shunt Trip DAQ Room | 1 = Shunt Trip AC A11 | 115 VAC | Dry Contact | Detector Clean Pow. |
| | 1 = Shunt Trip AC A12 | 115 VAC | Dry Contact | Detector Dirty Pow. |

| | | | | |
|---|---|---|---|---|
| | | 115 VAC | Dry Contact | |
| | | 115 VAC | Dry Contact | |
| | | 115 VAC | Dry Contact | |
| | | 115 VAC | Dry Contact | |

## 11.2 Table 3. List of Output signals from the STAR Global Interlock System

| STAR SYSTEM | Signal | Type of Signal | Source for Signal | Comments |
|---|---|---|---|---|
| TPC Gas System | 1=AC Enable, 0 = Off | 24 VDC | | AC for Gas Rack 2 |
| | 1=HV Enable, 0 = HV Off | 24 VDC | | Enables TPC HV |
| Magnet System | 1 = Enable<br>0 = Fast Shut off | 24 VDC | | This enables or removes magnet AC |
| | 1 = Enable<br>0 = Slow Shut off | 24 VDC | | This asks magnet to ramp down. |
| AC Circuit Breaker Shunt Trip<br>PLATFORMS | 1 = Shunt Trip AC 1A | 115 VAC | | Rack Row 1A |
| | 1 = Shunt Trip AC 1B | 115 VAC | | Rack Row 1B |
| | 1 = Shunt Trip AC 1C | 115 VAC | | Rack Row 1C |
| | 1 = Shunt Trip AC 2A | 115 VAC | | Rack Row 2A |
| | 1 = Shunt Trip AC 2B/I | 115 VAC | | Part of Row 2B |
| | 1 = Shunt Trip AC 2C | 115 VAC | | Part of Row 2B, part 2C |
| | 1 = Shunt Trip AC 3N | 115 VAC | | North Plat. Dirty Pow. |
| | Spare | 115 VAC | | Upgrade |
| | Spare | 115 VAC | | Upgrade |
| | Spare | 115 VAC | | Upgrade |
| | Spare | 115 VAC | | Upgrade |
| | Spare | 115 VAC | | Upgrade |
| | Spare | 115 VAC | | Upgrade |
| AC Circuit Breaker Shunt Trip<br>DAQ Room | 1 = Shunt Trip AC A11 | 115 VAC | | Detector Clean Power |
| | 1 = Shunt Trip AC A12 | 115 VAC | | Detector Dirty Power |
| | 1 = Shunt Trip AC A13 | 115 VAC | | DAQ.+Cntrl Room |
| | 1 = Shunt Trip DA | 115 VAC | | Rack Row DA |
| | 1 = Shunt Trip DB | 115 VAC | | Rack Row DC |
| | 1 = Shunt Trip AC Cnt Rm | 115 VAC | | Control Rm AC Power |
| Solenoid Valves for MCW | Valves for Platform Lev. 1 | | | Both supply + return |
| | Valves for Platform Lev. 2 | | | Both supply + return |
| | Valves for DAQ Room | | | Both supply + return |
| **Alarms** | Alarm in STAR Control | | | Enunciate STAR alarm |
| | Alarm in RHIC Cntrl Rm. | | | Send Alarm to RHIC |
| Notification | STAR Magnet going off | | | Send notif. To RHIC |
| | | | | |
| | | | | |

## 12. REPONSES OF THE STAR GLOBAL INTERLOCK SYSTEM

| Location | Fault | Table 4. Responses of the SGIS. | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Response of SGIS to Fault | | | | | | | | | | | | | |
| | | Slow Controls Notified | STAR Alarm Control | Alarm RHIC Control | Power to Rack Row Cut | Power to Detector cut (Trip A11 and A12) | Plat. Lev. Water off | DAQ Rm water off | Magnet ramped down | Magnet current fast off | TPC HV Enable is dropped | TPC purge after 10 minute delay | Immediate TPC gas purge TPC gas Enable dropped | Indication at P.V. of malf. Unit ID | STAR shift responds (if present, not SGIS) |
| Daq | Low level smoke alarm | X | X | | | | | | | | | | | | X |
| Daq | High level smoke alarm | X | X | X | X | | | | | | | | | | X |
| Plat. | Low level smoke alarm | X | X | | | | | | | | | | | | X |
| Plat. | High level smoke alarm | X | X | X | X | | | | | | | | | | X |
| Plat. | Heat Alarm | X | X | X | X | | | | | | | | | | X |
| Det. | Low level smoke alarm | X | X | | | | | | | | | | | | X |
| Det. | High level smoke alarm | X | X | X | | X | | | X | | X | X | | | X |
| Det. | HSSD Malfunction | X | X | | | | | | | | | | | X | X |
| Daq | Rack $H_2O$ leak | X | X | | X | | | X | | | | | | | X |
| Plat. | Rack $H_2O$ leak | X | X | | X | | X | | | | | | | | X |
| Det. | $H_2O$ leak | X | X | | | | | | X | | X | | | | X |
| Any | Tracetek Malf. | X | X | | | | | | | | | | | X | X |
| Mag. | Minor $H_2O$ leak | X | X | | | | | | | | | | | | X |
| Det. | Low level gas alarm | X | X | | | | | | | | | | | | X |
| Det. | High level gas alarm | X | X | X | | X | | | X | | X | | X | | X |
| Det. | Flam. Gas Det. Malf. | X | X | | | | | | | | | | | X | X |
| Any | Valve fails to close | X | X | | | | | | | | | | | X | X |