Report of the Tunnel Safety Working Group

**Superconducting Super Collider
Laboratory**

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Report of the Tunnel Safety Working Group

J. Gannon

Superconducting Super Collider Laboratory*
2550 Beckleymeade Ave.
Dallas, TX 75237

April 1991

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Superconducting Super Collider Laboratory

2550 Beckleymeade Avenue
Dallas, TX 75237-3946

Report of the Tunnel Safety Working Group

April 1, 1991

1.0 Introduction

On 18 February 1991 the Project Manager formed a working group to address the safety guidelines and requirements for the underground facilities during the period of accelerator construction, installation, and commissioning. The following report summarizes the research and discussions conducted by the group and the recommended guidelines for safety during this phase of the project.

2.0 History

Previous studies¹ along with discussions and agreements with and rulings by DOE² established equivalency to NFPA 101M Life Safety Code³ for exit spacing and tunnel safety features which will be in place for the operational phase of the accelerator. During civil construction the OSHA Regulations for Construction and Industrial Safety (29 CFR 1926/1910) will be adhered to by SSCL, PB/MK, and the construction contractors³. The period between civil construction and operation, where the accelerator systems are installed, has not been addressed by studies in the past. It is this period that this working group will address. Civil construction, for the purposes of this document, is defined as the period of physical construction of the tunnels and the installation of permanent utilities such as electrical power, lighting, ventilation systems, fire alarm and protection systems, etc., under the direction of the AE/CM. Operation is defined as the period where tests and commissioning of major subsystems begins.

3.0 Underground Construction

OSHA Regulations governing underground construction are covered under 29 CFR 1926 Subpart S. This subpart defines systems, procedures, safety equipment, etc needed

¹SSC Safety Review Document, T.E. Toohig, Editor, SSC-N-1037, November 1988, and *Study and Findings Concerning Egress Spacing and Life Safety*, Working Group on Safety Codes for Underground Accelerator Operations, SSC-N-1042, 10 November 1989.

²SSC Emergency Egress Design Features, DOE Memorandum EH-1-322, 27 September 1990.

³SSC Egress Provisions and Features for Evaluation of Equivalency as per Chapter 7 of NFPA 101M, L. Coulson and T. Toohig, Internal Document, 5 May 1990.

for underground construction. Copies of memoranda related to the Subpart S requirements are reproduced in Appendix 1. The working group concurs after reviewing other regulations that Subpart S and the rest of 29 CFR 1926 & 1910 are the proper regulations to follow during tunnel construction as was previously suggested³.

4.0 Accelerator Systems Installation

This phase of the project involves installing accelerator equipment in completed segments of underground enclosures and shaft areas (i.e. the entire enclosure of an accelerator is not complete). It begins after the area is turned over to the SSCL by PB/MK for beneficial occupancy and ends when large scale tests and commissioning of subsystems begins. Completed tunnel segments would have permanent power, lights, fire alarm systems, etc. Permanent or temporary ventilation systems will be present during this phase. A permanent stairway and elevator will be present. Tunnel segments may have only one normal entry or egress point during this phase. Adjacent segments of tunnel still under the civil construction phase will be separated from completed ones by a two hour fire rated barrier wall with an alarmed door for emergencies. It is intended that access from either direction in an emergency will be allowed, subject to OSHA concurrence. Communications to the "designated person" at the top of the shaft, as required by Subpart S, will need to be provided to inform this safety person of the nature and extent of the emergency.

Personnel installing accelerator systems will be SSCL staff, SSCL subcontractors, and temporary contract personnel all under direct or indirect supervision by SSCL staff. Disciplines include but are not limited to technicians, engineers, physicists, welders, pipefitters, riggers, electricians, surveyors, and of course safety personnel. Equipment installed during this period includes; magnet stands and magnets, RF cavities, cable trays, conventional and fiber optic cables, gas and LCW piping, cryogenic systems, equipment racks, control systems, magnet power supplies and other electronics, beam monitors, safety interlock systems, etc. Activities involved with installation of these systems are; magnet stand and magnet survey, magnet interconnections, vacuum leak checking, subsystem interconnections, preliminary checkout of control systems and connections, etc.

Appendix 2 is an estimate of the activities in a typical sector of the Collider and the crew size for each of the activities during installation and initial checkout. These activities are roughly in sequence with some parallel efforts. Crew sizes for the HEB should be roughly equal and they would be much smaller for the other accelerators due to their smaller size and conventional magnets. The number of personnel, activities, and the hazards of these activities in process at any one time underground is a matter of concern. The maximum number of personnel and the hazards of their activities must be identified more clearly and be subject to a detailed and quantitative safety risk assessment.

The working group after studying the problems of accelerator installation, concluded that OSHA 29 CFR 1926 & 1910 regulations should apply during accelerator installation. Subpart S regulations do not directly apply as this is not civil construction. However, the group believes that most of Subpart S should be used because of the "common sense" safety guidelines it provides. Additionally the barrier wall with a door provides a second means of escape not required by Subpart S but the group recommends as a "good practice" when implemented. Subpart S includes regulations and guidelines that address logging of personnel, ventilation, fire protection and fire fighting apparatus, air quality monitoring, flammables, gas cylinders, training, etc.

5.0 SubSystem Commissioning and Tests

This phase of the project involves large scale start-up, debugging, and testing of accelerator systems prior to beam commissioning. In the smaller accelerators this would be mainly limited to initial start-up testing and debugging of magnet and RF power systems as these machines do not have cryogenic systems. The HEB and Collider would include start-up of the cryogenic refrigerators and cooldown of the magnet systems before magnet power system tests could begin.

At this point, for each of the machines, the hazard levels increase. Oxygen Deficiency Hazards (ODH) are present in the HEB and Collider and electrocution hazards and X-ray hazards could be present from magnet and RF power systems respectively. Long strings of powered magnets also present hazards from large amounts of stored energy.

Measures to mitigate these hazards involve increased levels of safety appropriate to the hazard. Access to ODH areas will be limited to qualified personnel and access will be further restricted when magnets are to be powered. Personnel safety interlock systems will need to be operational before magnet or RF systems are powered. Radiation monitoring systems will need to be instituted for powering of RF Cavities.

All of these increased hazards force the safety and egress provisions to be more stringent. At this point the group feels that this is when the "key is first turned" to start up the machine and the NFPA 101M equivalency^{2,3} should first apply. This implies two methods of egress from each tunnel section into two hour fire rated enclosures along with other provisions of NFPA 101M and the allowed equivalency.

Depending on the results of the quantitative safety and hazard analyses for each accelerator, barriers appropriate to the hazards involved will need to be constructed to separate sections undergoing commissioning tests from those where civil construction or accelerator installation is taking place.

A possible sequence of civil construction is given in Appendix 3. The Collider is the only machine whose civil construction is not under one contract. The problems this presents are detailed below.

6.0 Collider Specific Problems

6.1 Installation of Magnets

There are presently five magnet installation shafts. This requires that magnets will need to be, in some cases, delivered from the shaft, through ODH sectors past cold magnets, to the installation sector. The magnet delivery crew will thus need to be ODH qualified. Their passage from ODH to installation areas and visa versa will need to be logged to satisfy Subpart S and SSCL safety requirements. A trained person on the non ODH side of the barrier wall would only open and allow their passage through the door after determining that an oxygen deficiency does not exist on the ODH side of the wall. This person would also prevent passage of untrained and unqualified personnel into the ODH restricted area. Communication with the surface "designated persons" would log their passage and log the closing and locking of the door to re-establish safety controls. Magnet systems would not be powered while magnets are being delivered through these sectors.

Other accelerator systems should be able to be delivered through personnel shaft elevators or lowered through shafts other than the magnet shaft which are outside of the ODH areas. Exceptions to this will be addressed on a case by case basis when they are identified.

6.2 Underground String Test

A possible underground test of a short string of magnets has been proposed for the N15 (E1) area. To accomplish this, in a partially completed tunnel, barrier walls for the ODH area would have to be constructed. The safeguards for installation outlined above would be implemented for passage of personnel and equipment. This test is viewed as an operational phase and therefore requires two rated exits to the surface as per the SSC Egress report.³ The present N15 design has a rated personnel shaft at one end of the string test and the magnet delivery shaft at the other. A temporary rated exit would need to be constructed in the magnet shaft to satisfy the egress requirements. This temporary exit could remain until the end of Collider installation when radiation shielding is installed in this shaft. There is likely to be activity at this installation point for many years and a safe exit from this shaft makes good common sense. However, it should be noted that this temporary exit will be expensive in a deep shaft.

7.0 Summary

The study group feels that this interpretation of the applicable codes and regulations is correct, proper, and will allow the accelerator to be constructed, installed, and commissioned in a safe manner. This interpretation and judgement gives cognizant individuals, groups, and authorities a basis for evaluation of and compliance with these proposed safety criteria and regulations.

More effort, which is outside the scope of this group, remains. A thorough quantitative risk and hazard assessment should be done. This could be done by an independent outside group in residence at SSCL or by a bolstered SSCL safety staff. Plans and procedures need to be written, reviewed, and adopted well in advance so that milestones are not missed.

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8.0 Working Group MembershipSignatureDate

Jeffery Gannon, Chairman, ASD/EE

Jeffery C. Gannon4 | 1 | 91

Roy Prince, CCD Construction

Roy Prince4 | 1 | 91

Barry Hendrix, PM/Safety

Barry Hendrix4 | 1 | 91

Ray Nations, ASD Safety

Ray Nations4 | 1 | 91

Bill Dorn, E S & H

Bill Dorn4 | 1 | 91

Jeff Bull, E S & H

Jeff Bull4 | 1 | 91

Tim Toohig, CCD

Tim Toohig4 | 1 | 91

Tom Dombuck, ADOD

T. Dombuck4 | 1 | 91

Larry Sauer, ASD/ME

L. Sauer4 | 1 | 91

Bill Fietz, ASD/Cryo

__________|_____|_____|

Dan Whiting, PB/MK

__________|_____|_____|

F. Larvie, PB/MK

F. C. Larvie4 | 1 | 91

*Superconducting Super Collider Laboratory
2550 Beckleymeade, Building #4, MS 2011
Dallas, Texas 75237-3946
(214) 708-4006*

MEMORANDUM

CONVENTIONAL CONSTRUCTION DIVISION

TO: Jeff Gannon--Tunnel Egress Working Group
FROM: Roy Prince & Dan Whiting
DATE: March 6, 1991
SUBJECT: Possible Egress Methods During Construction

You had asked that we provide a list of egress methods used by the contractors during the construction of tunnel. These methods assume that the permanent fire rated stairs and/or permanent elevator have not been installed so the contractor must use temporary methods.

OSHA 1926, Subpart "S" says the following about Access & Egress---

.300,(b) (1)-"The employer shall provide and maintain safe means of access and egress to all work stations."

.300, (g) Emergency provisions-(1) Hoisting capability. "When shaft is used as a means of egress, ...make advance arrangements for power-assisted hoisting capability to be readily available in an emergency, unless regular hoisting means can continue to function in the event of an electrical power failure at the job site....."

Options available to a contractor for temporary access and egress:

1. Ladders-- usually not feasible when over 75 feet deep. Must provide a cage around the ladder or equip the ladder with a safety belt attachment if over 20 feet high. Normally you see these as an emergency backup system to be used only if the primary system fails.
2. Temporary stairs -- these are usually constructed with steel scaffolding tubes. Maximum height around 75 feet. Easy to go down the shaft but difficult to exit.
3. Temporary elevator cage -- these are what you see on the side of a high rise building to bring workers and material to the upper levels. Can't install during shaft excavation.

APPENDIX 1

Memo to:

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Good method if the shaft will be used for a medium (months not days) period of time. Can be adapted for deep shafts.

4. Manlift cage raised & lowered by crane-- Flexible system that is good during mucking operations. A crane would already be required for the mucking operation. Could be used while still excavating the shaft. These manlifts can also be raised/lowered by an independent power source. Normally a separate electric motor is used to raise the manlift.

5. Others - Sometimes one will see a special adaptation developed for shaft access but these are not commercially available items.

*Superconducting Super Collider Laboratory
2550 Beckleymeade, Building #4, MS 2011
Dallas, Texas 75237-3946
(214) 708-4006*

MEMORANDUM

CONVENTIONAL CONSTRUCTION DIVISION

TO: Jeff Gannon--Tunnel Egress Working Group
FROM: Roy Prince
DATE: March 6, 1991
SUBJECT: OSHA Requirements During Construction

Attached is a copy of the OSHA Part 1926 dated June 1, 1989.

The pertinent parts of the standard for the SSC Laboratory's installation of the systems are as follows:

- a. SSC must control access to the tunnel.
- b. Must provide a check-in/check-out procedure. This is usually done with a metal tag system for each employee and contractor. See exception.
- c. Must train all employees.
- d. Must establish communication.
- e. Must provide 2 effective means of communication
- f. Provide back-up hoisting means for the shafts.
- g. Provide self rescuers.
- h. Provide "designated person" above ground.
- i. Provide emergency lighting.
- j. Provide rescue teams.
- k. Provide "competent person" to perform air monitoring.
- l. Provide ventilation--200 cf per minute per person + 100 cf per horsepower of diesel engine.
- m. If use temporary manlift or cage, must meet the requirements on pages 157-8.

Bottom line-- the OSHA procedures are pretty much based on common sense and experience all over the country. Most are easy to understand. PB/MK will be training the contractor people and using these OSHA standards. They could assist the Lab. in the implementation of the OSHA standards. The local OSHA people have also indicated a willingness to assist the contractors in understanding the safety rules.

APPENDIX 1

Estimate of Collider Underground Construction & Installation Activities in a Typical Arc Sector

(Includes tunnels, niches, alcoves, & shafts)

<u>Construction or Installation Activity</u> (In approximate order of occurrence)	<u>Div</u>	<u>Crew Size</u>	
		Lab	Contract
Tunnel Boring and Niche Construction	CCD	TBD by	
Tunnel Floor and Concrete Finishing Work	CCD	PB/MK	
Electrical Power, Ventilation, Alarms, etc., Install	CCD	Contractors	
Monument Survey	ADOD	8	0
Magnet Stand Position Survey	ADOD	3	0
Magnet Stand Installation	ASD	1	3
Technical Cable Tray Installation	ASD	1/2	8
Equipment Rack Installation	ASD	1/2	7
Technical Cable Installation and Termination	ASD	2	16
Fiber Optic Cable Installation	ASD	1	6
Electrical/Radiation Safety System Installation	ASD	2	2
Warm Gas Piping Installation	ASD	2	6
Cryogenic Piping Installation (Shaft to Alcove)	ASD	2	6
DC Power Bus Install (Shaft to Alcove E & F Sites)	ASD	1/2	8
Tunnel Electronics Installation (partial)	ASD	6	6
Magnet and Spool Installation	ASD	1	10
Magnet Survey	ADOD	4	0
Vacuum Interlocks & Controls Operational	ASD	4	0
Magnet Connect, Vac Hardware Install, & Leak Check	ASD	10	45
Connect & Check Cryogenic Controls	ASD	4	0
Install, Connect, & Check Other Electronic Systems	ASD	16	0
Cryogenic System Safety Checks	ASD	TBD	
Cooldown Magnets	ASD	TBD	
Electrical Safety System Tests & Other Safety Checks	ASD	TBD	
Quench Protection System Tests/Checkout	ASD	TBD	
Power Sector or Half Sector	ASD	0	0
Install Radiation Shielding Walls, Plugs, Etc	CCD	<u>TBD</u>	
	Totals	67	127

APPENDIX 2

Superconducting Super Collider Laboratory
2550 Beckleymeade, Building #4, MS 2011
Dallas, Texas 75237-3946
(214) 708-4006

MEMORANDUM

CONVENTIONAL CONSTRUCTION DIVISION

TO: Jeff Gannon--Tunnel Egress Working Group
FROM: Roy Prince *RP*
DATE: March 8, 1991
SUBJECT: Construction Sequence--CCD Plan

The exact sequence of contracts and construction is still under review. PB/MK and CCD are attempting to optimize the underground construction process.

Our current plan for conventional construction of the tunnel;

- 2 contracts per tunnel segment

- first contract will bore the tunnel & place the tunnel lining

- second contract will install all conventional finish items in the tunnel to incl niches
finish items include-tunnel floor with drainage, cable tray for DC power and signal, electrical power (69 KV circuit, 12.47 KV cable, power to niches, power for lights), lights

the shafts will also completed before transfer to the SSCL.

all elevators and stairs will be in place and available for use by the systems installers

The plan is to complete a segment of tunnel by the excavation contractor then turn that segment over to the "finishout" contractor. When the second contractor has corrected all punchlist items, this segment of tunnel will be transferred to the Lab. for installation of the technical systems. The conventional construction for the shafts will also be finished before transfer to the Lab.

There are several different possibilities for the construction of the shafts and tunnels. The current baseline schedule is subject to change but the plan is as follows:

E-1 Utility Shaft	BOD to Lab=Jan 94
E-1 Personnel Shaft	BOD =Jan 94
E-1 Magnet Delivery Shaft	BOD=Jan 94
Tunnel E-1 to E-2	BOD=Jan 94

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Tunnel E-2 to F-2

etc. see sketch

BOD=Feb. 94

Several items have not been finalized but here is the current plan.

ventilation system- this system is tied to the completion of the headhouses. For planning purposes- assume that temporary ventilation must be provided.

permanent monitor system for oxygen, etc-----The contract requirements for these systems are still being developed.

emergency exit lights

For planning purposes- assume these

permanent fire extinguishers

system are not in place when the technical systems are being installed.

permanent security system

permanent personal transporter

This system is not in the CCD contracts

permanent communications

Not in CCD contract