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**X-RAY AND NUCLEAR RADIATION FACILITIES,
PERSONNEL SAFETY FEATURES**

W. J. Mason
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October 1976

**UNION
CARBIDE**

**OAK RIDGE Y-12 PLANT
OAK RIDGE, TENNESSEE**

*prepared for the U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
under U.S. GOVERNMENT Contract W-7405 eng 26*

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Prepared for the US Energy Research
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ABSTRACT

Development and implementation of these standards are described and the general philosophy and approach to these standards are outlined. Use of a matrix (type of installation versus radiation safety feature) to facilitate equipment classification and personnel safety feature requirements is presented. Included is a set of the standards showing formats, matrices, etc, and the detailed standards for each safety feature.

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INTRODUCTION

The Oak Ridge Y-12 Plant^(a) is a research and production installation. The nature and versatility of this work require the use of a large number and variety of X-ray and radiographic sources for nondestructive testing and material analyses. Presently, there are over 80 X-ray generators in the Plant, which range in size from small, portable units which operate at a less than 50 kilovolts potential and 0.1 milliamperes current to an electron linear accelerator which operates at 12-million electron volts and produces a radiation beam of such intensity that it could deliver a lethal dose to man in a fraction of a minute. There are also almost 50 gamma and neutron sources in use in the Plant. These units range in size from a few millicuries to several hundred curies.

The Plant's approach to safety in these facilities has been to consider specific features for each at the time of its design. Such an approach over the period of the last twenty-five years resulted in a multiplicity of combinations and types of safety features. In order to assure consistency and adequacy of the radiation safety features in future installations as well as to develop criteria for upgrading present installations, engineering standards were developed for the safety circuits and equipment associated with such installations.

Although the radiation safety at each of these facilities was considered adequate, the administrative and maintenance procedures became unduly complicated. Accordingly, Engineering standards and uniform operating procedures were considered necessary to alleviate these complications and, in so doing, provide an improved measure of radiation safety.

(a) Operated by the Union Carbide Corporation's Nuclear Division for the US Energy Research and Development Administration.

PREPARATION OF STANDARDS

The first step in the preparation of these standards was the development of a set of guidelines by a committee of Plant specialists representing the operations, maintenance engineering, and radiation safety groups.

The guidelines incorporated the following major points:

1. Standards should meet or exceed the requirements in nationally accepted standards.
2. Shielding of the radiation field should be accomplished whenever feasible.
3. Interlocks and other safety and warning features should be provided to supplement or complement the safety afforded by enclosures.
4. Use of shielding and/or other radiation safety features should be commensurate with the level of radiation and/or exposure potential.

Engineering standards were developed for the definition and classification of X-ray and nuclear radiation facilities and for the specification of various personnel safety features required for these facilities. A matrix (Section ES-1.9-2) was prepared to list, in concise form, the personnel safety features that were either required, optional, or not applicable to each facility classification. The matrix illustrates not only that different classifications of X-ray and nuclear radiation facilities require different personnel safety features, but that differences in radiation level and exposure potential within each facility classification justify the requirement of more safety features for some facilities than others. Facility classifications are described in Sections ES-1.9-3 through 13, along with definitions, schematics with illustrations, and listings of personnel safety feature requirements.

Detailed information on personnel safety features including definitions, descriptions, example of approved circuitry and/or equipment, devices, etc, is contained in Sections ES-1.9-14 through 47.

ACKNOWLEDGEMENTS

These standards for radiation safety features at nondestructive testing and material analysis facilities were fostered and approved by a committee of the following Y-12 personnel: T. H. Barton, L. E. Burkhart, V. C. Jackson, D. A. Jones, C. M. Knowles, D. L. Mason, W. J. Mason, J. D. McLendon, G. W. Oliphant, E. W. Pipes, E. Roberts, Jr, T. R. Rucker, D. N. Smith, H. G. Smith, S. G. Snow, L. M. Van Arsdall, and C. M. West. A task group consisting of W. J. Mason, E. W. Pipes, T. R. Rucker, D. N. Smith, and C. M. West was selected to carry out the detailed development of the standards. E. W. Pipes and H. W. Zang were responsible for preparing the engineering details of the standards.

X-RAY AND NUCLEAR RADIATION FACILITIES PERSONNEL SAFETY FEATURES—PREFACE

ES-1.9-1

SCOPE

This standard outlines design requirements for specification, procurement, or construction of safety devices for installation on X-ray and nuclear radiation facilities to assure protection of personnel from harmful ionizing radiation.

APPLICABLE STANDARDS

Unless otherwise specified in this standard or on the drawings, the latest revision of the following standards shall apply as minimum requirements for the manufacture, installation, operation, use, and maintenance of industrial equipment which may give off radiation from radioactive materials or X-rays:

ANSI Z54.1-1963 - "Safety Standard for Non-Medical X-Ray and Sealed Gamma-Ray Source."

Y-12 Plant Health and Safety Manual, Volume 1, Procedure 70-100, "Health Physics and Industrial Hygiene."

Y-12 Plant Health and Safety Procedures, Volume 1, Procedure 70-102, "X-Ray Equipment and Radioactive Sources."

GENERAL

For purposes of this standard, all X-ray and nuclear radiation sources are classified by type of operating or storage facility. Personnel safety features are classified and described according to safety function. A descriptive matrix, Engineering Standard ES-1.9-2, designates required or optional safety features applicable to each classification of radiation facility. An "X" symbol at a matrix junction indicates that the safety feature is required (shall be installed) on the radiation facility. Exceptions for specific facilities will be authorized only after review and concurrence of a safety features review committee. An "O" symbol at a matrix junction indicates that need for the safety feature on any particular radiation facility will be determined by a safety features review committee.

Radiation facility type numbers (derived from top of the matrix) and safety feature device numbers (from left side of matrix) are used throughout these standards for identifying, classifying, and describing the radiation facilities and safety devices.

These safety standards apply to industrial applications of X-ray and nuclear radiation facilities and supplement the requirements as set forth in ANSI Z54.1-1963 and Y-12 Plant Health and Safety Manual Procedures 70-100 and 70-102.

RADIATION MONITORING DEVICE		OPEN SHIELD PILOT RELAY
RADIATION MONITOR AUX. DEVICE		SYSTEM ENERGIZING CONTACTOR AUX. RELAY
BELL		CLOSE SHIELD PILOT RELAY
HORN		OPEN SHIELD MOTOR STARTER
HORN SILENCE RELAY		SHIELD OPENED AUX. RELAY
LINE CONTACTOR		CLOSE SHIELD MOTOR STARTER
SYSTEM ENERGIZING CONTACTOR		SHIELD CLOSED AUX. RELAY
SYSTEM ENERGIZING REDUNDANT CONTACTOR		LINE ON (RED LIGHT)
FLASHER MOTOR		SYSTEM ARMED (AMBER LIGHT)
VOLTAGE SENSING DEVICE		SYSTEM ON (RED OR MAGENTA LIGHT)
VOLTAGE SENSING RELAY		X-RAY OFF/SOURCE SHIELDED (GREEN LIGHT)
VSD AUX. RELAY		SHIELD OPEN/SOURCE IN OPERATING POSITION (WHITE LIGHT)
LIGHT FAILURE DEVICE		AUX. INTERLOCK DEVICE (YELLOW LIGHT)
LIGHT FAILURE RELAY		SOLENOID DOOR LOCK
LIGHT FAILURE AUX. RELAY		TIME DELAY RELAY
FAIL STRIP DEVICE	TDR-1	VOLTAGE TIME DECAY TIME DELAY
FAIL STRIP RELAY	TDR-2	BELL TIME DELAY
FAIL STRIP AUX. RELAY	TDR-3	HORN TIME DELAY
RIBBON SWITCH	TDR-4	DUAL HEAD, VOLTAGE TIME DECAY AND HORN TIME DELAY
SOLENOID OPERATED SWITCH		

TDR-5	FORCED INSPECTION TIME DELAY		ZENER DIODE
TDR-6	LIGHT FAILURE TIME DELAY		FUSE
TDR-7	LIGHT FAILURE TIME DELAY		OVERLOAD HEATER ELEMENT
PB-RL	LIGHT FAILURE DEVICE RESET PUSHBUTTON		RESISTOR, VARIABLE
PB-IL	LIGHT FAILURE DEVICE TEST PUSHBUTTON		NORMALLY OPEN CONTACTS
PB-FI	FORCED INSPECTION PUSHBUTTON		NORMALLY CLOSED CONTACTS
N. O. LIMIT SWITCH		TRANSFORMER
N. C. LIMIT SWITCH		ELECTRONIC AMPLIFIER
SWD	DOOR LOCK SWITCH		CIRCUIT EMPHASIS AREA OUTLINE
SWK	SYSTEM KEY LOCK-OUT SWITCH		SHUTTER SOLENOID
SWI	FORCED INSPECTION KEY LOCK-OUT SWITCH		SHUTTER AUX. RELAY
DOOR CLOSE STARTER		SOURCE AUX. RELAY
DOOR OPEN STARTER		EXTEND SOURCE MOTOR STARTER
VOLTAGE REGULATOR TUBE		RETRACT SOURCE MOTOR STARTER
KILOVOLT METER		EXTEND SOURCE AUX. RELAY
KILOVOLT PEAK METER		RETRACT SOURCE AUX. RELAY
MILLIAMMETER		SOURCE EXTENDED RELAY
RESISTOR, FIXED		SOURCE RETRACTED RELAY
CAPACITOR	PB-ES	EXPOSE SOURCE RED PUSHBUTTON
RECTIFIER	PB-SS	SHIELD SOURCE GREEN PUSHBUTTON

PB-LS EMERGENCY LOWER SOURCE RED PUSHBUTTON

PB-LC-ON LINE CONTROL ON RED PUSHBUTTON

PB-LC-OFF LINE CONTROL OFF GREEN PUSHBUTTON

PB-X-ON X-RAY ON RED PUSHBUTTON

PB-X-OFF X-RAY OFF GREEN PUSHBUTTON

MATRIX

ES-1.9-2

PERSONNEL SAFETY FEATURES		CLASSIFICATION OF FACILITIES											
		I. X-RAY & NEUTRON GENERATING EQUIPMENT (PROCESS, DEVELOPMENT & ANALYTICAL)				II RADIOACTIVE SOURCES					III SPECIAL X-RAY AND/OR RADIOACTIVE DEVICES		
		A. OPERATING FACILITIES			B. STORAGE FACILITIES ES-1.9-7	A. OPERATING FAC: ≥ 50 MILLI-CURIES			B. STORAGE FACILITIES ES-1.9-11	C. OPERATING FAC: < 50 MILLI-CURIES ES-1.9-12	A. NON-VACUUM ELECTRON BEAM WELDERS ES-1.9-13	STANDARDS	
		1. VAULT ES-1.9-4	2. ENCLOSED BEAM ES-1.9-5	3. OPEN BEAM ES-1.9-6		1. VAULT ES-1.9-8	2. ENCLOSED BEAM ES-1.9-9	3. OPEN BEAM ES-1.9-10					
CIRCUIT DEVICES		① MAIN DISCONNECT SWITCH	X	X	X	-	X	O	O	-	-	X	ES-1.9-14
INTERLOCKS		② MILLIAMPS & KILOVOLT METERS	X	X	X	-	-	-	-	-	-	X	ES-1.9-15
		③ SYSTEM ENERGIZING CONTACTOR	X	X	X	-	O	O	O	-	-	X	ES-1.9-16
		④ VOLTAGE-SENSING DEVICE	X	X	X	-	-	-	-	-	-	X	ES-1.9-17
		⑤ RADIATION MONITOR	O	-	-	-	X	O	O	O	-	O	ES-1.9-18
		⑥ SOLENOID DOOR LOCKS	O	-	-	-	X	-	-	O	-	O	ES-1.9-19
		⑦ VOLTAGE TIME DECAY CONTROL	X	X	X	-	-	-	-	-	-	X	ES-1.9-20
		⑧											
		⑨ ACCESS DOOR	X	O	O	-	X	O	O	-	-	X	ES-1.9-22
		⑩ ENCLOSURE PANELS	-	X	X	-	-	O	O	-	-	O	ES-1.9-23
		⑪ RADIATION SHIELD	O	O	O	-	X	O	O	-	-	O	ES-1.9-24
		⑫ BARRICADE	-	O	O	-	-	O	O	-	-	-	ES-1.9-25
		⑬ SCRAM SWITCH	X	-	O	-	X	-	-	-	-	O	ES-1.9-26
		⑭ FORCED INSPECTION	O	-	-	-	O	-	-	-	-	O	ES-1.9-27
		⑮ RADIATION BEAM POSITION	O	O	O	-	O	O	O	-	-	-	ES-1.9-28
		⑯ LIGHT FAILURE	O	O	O	-	O	O	O	-	-	O	ES-1.9-29
		⑰ KEY LOCK-OUT	O	O	O	-	O	O	O	-	-	O	ES-1.9-30
		⑱ FAIL STRIP	O	-	-	-	O	-	-	-	-	-	ES-1.9-31
⑲													
VISUAL WARNING DEVICES		⑳ SIGNS	X	X	X	X	X	X	X	X	X	ES-1.9-33	
LIGHTS		㉑ LINE ON	X	X	X	-	X	O	O	-	-	X	ES-1.9-34
		㉒ SYSTEM ARMED	O	O	O	-	O	O	O	-	-	-	ES-1.9-35
		㉓ SYSTEM ON--STEADY	X	X	X	-	X	O	O	-	-	X	ES-1.9-36
		㉔ SYSTEM ON--FLASHING	X	X	X	-	X	O	O	-	-	X	ES-1.9-37
		㉕ VSD ON/SOURCE EXPOSED--FLASHING	X	X	X	-	X	O	O	-	-	X	ES-1.9-38
		㉖ SHUTTER OPEN--FLASHING	-	-	O	-	-	-	O	-	-	-	ES-1.9-39
		㉗ SHUTTER CLOSED--STEADY	-	-	O	-	-	-	O	-	-	-	ES-1.9-40
AUDIBLE WARNING DEVICES		㉘ X-RAY OFF/SOURCE SHIELDED	O	O	O	-	X	O	O	-	-	O	ES-1.9-41
		㉙											
		㉚ BELL	X	-	-	-	X	-	-	-	-	X	ES-1.9-43
		㉛ HORN	O	-	O	-	O	-	O	-	-	O	ES-1.9-44
		㉜											
PHYSICAL RESTRAINTS		㉝ BARRICADES	O	O	X	-	O	O	X	O	O	ES-1.9-46	
㉞ PADLOCKS	O	O	O	O	O	O	O	O	X	O	O	ES-1.9-47	
㉟													

X REQUIRED AS NOTED IN DEFINITION. EXCEPTIONS FOR SPECIFIC FACILITIES WILL BE AUTHORIZED ONLY AFTER REVIEW AND CONCURRENCE OF A SAFETY FEATURES REVIEW COMMITTEE

O SPECIAL - EACH CATEGORY SO NOTED SHALL BE CONSIDERED ON AN INDIVIDUAL BASIS. DECISION AS TO NEED SHALL BE RESOLVED BY A SAFETY FEATURES REVIEW COMMITTEE.

- NOT APPLICABLE

FACILITIES' CLASSIFICATION AND DESCRIPTION	ES-1.9-3
---	-----------------

A. VAULT FACILITY - TYPE IA1 (REFERENCE ES-1.9-4) OR TYPE IIA1 (REFERENCE ES-1.9-8)

A vault facility is a permanent enclosure for radiation-producing equipment or sources large enough for personnel to bodily enter but within which no person is permitted to remain during irradiation.

The permanent enclosure is most frequently a shielded room with a maze and/or shielding door. Reliable safety features are provided to prevent access to the enclosure during irradiation. Engineering design of personnel safety features for vaults will meet or exceed the requirements for an "exempt protective installation" as prescribed in N.B.S. Handbook #93, "Safety Standards for Non-Medical X-Ray and Sealed Gamma-Ray Sources."

B. ENCLOSED BEAM FACILITY - TYPE IA2 (REFERENCE ES-1.9-5) OR TYPE IIA2 (REFERENCE ES-1.9-9)

An enclosed beam facility is a permanent enclosure for radiation-producing equipment or sources so designed that the radiation is enclosed by a physical barrier in such a way that it is not accessible for personnel exposure.

An enclosed beam facility differs from a vault facility in that it is not large enough for personnel to enter. If there are doors, removable shields, etc., which permit personnel access to the locations where there would be radiation, reliable safety features are provided to prevent irradiation during such access. Engineering designs of personnel safety features for enclosed beam facilities will meet or exceed the requirement for "exempt protective installation" as prescribed in N.B.S. Handbook #93, "Safety Standards for Non-Medical X-Ray and Sealed Gamma-Ray Sources".

C. OPEN BEAM FACILITY - TYPE IA3 (REFERENCE ES-1.9-6) OR TYPE IIA3 (REFERENCE ES-1.9-10)

An open beam facility is a facility with radiation-producing equipment or sources which is not enclosed or contained in a vault.

An open beam facility is used only when operating requirements are such that the inherent degree of protection provided by the vault or enclosed beam facility is not feasible. Engineering design of personnel safety features for open beam radiation facilities will meet or exceed the requirements for "open protective installations" as prescribed in N.B.S. Handbook #93, "Safety Standards for Non-Medical X-Ray and Sealed Gamma-Ray Sources."

D. STORAGE FACILITY - TYPE IB (REFERENCE ES-1.9-7) OR TYPE IIB (REFERENCE ES-1.9-11)

A storage facility is an area or enclosure used for the storage of sources or radiation-producing equipment.

Radiation-producing equipment and sources which are not in current use fall into a storage-facility category. The above should also meet storage facility requirements if they are currently in use but are left unattended. Some examples of storage facilities are storage rooms, areas, storage pigs for large sources, desk drawers, and file cabinets for small sources.

E. RADIATION SOURCE LESS THAN 50 MILLI-CURIES - FACILITY TYPE IIC (REFERENCE ES-1.9-12)

Any nuclear radiation source of less than 50 milli-curies that is used in an operating facility.

E. CONTINUED

Some examples of this type radiation facility are:

1. Radioactive paint on gas filled electronic tubes to cause gas ionization.
2. Radiation sources used as components of signal sensors in smoke detectors and other electronic instruments.
3. Radiation sources used as failsafe elements in radiation-monitor systems.

F. NONVACUUM ELECTRON BEAM WELDERS - FACILITY TYPE IIIA (REFERENCE ES-1.9-13)

An electron beam welder in which the electron beam is not enclosed in a vacuum chamber.

Although an electron beam welder is not for the purpose of producing radiation, the fact that such welders operate at relatively high amperages and voltages make them highly effective X-ray generators. Consequently nonvacuum electron beam welder facilities must be installed with radiation safety features which are equivalent to safety features on X-ray machines of equal exposure potential.

X-RAY VAULT (TYPE IA1)

ES-1.9-4

NOTES

1. FOR DESCRIPTION OF ITEMS SEE SHEET #2 & #3.
2. HOLES IN BARRIERS FOR PIPES, DUCTS, CONDUITS, ETC. SHALL BE PROVIDED WITH BAFFLES TO INSURE THAT THE OVERALL PROTECTION AFFORDED BY THE BARRIER IS NOT IMPAIRED. THESE HOLES SHOULD BE LOCATED OUTSIDE THE RANGE OF POSSIBLE ORIENTATION OF THE USEFUL BEAM.

GENERAL

THIS STANDARD OUTLINES THE REQUIREMENTS FOR EQUIPPING VAULT TYPE X-RAY FACILITIES WITH SAFETY DEVICES TO PROTECT PERSONNEL FROM HARMFUL IONIZING RADIATION.

REQUIREMENTS

IT IS REQUIRED THAT VAULT TYPE X-RAY FACILITIES BE EQUIPPED WITH THE FOLLOWING SAFETY FEATURES: THESE ITEMS ARE NOTED BY AN "X" SYMBOL ON ES-1.9-2. EXCEPTIONS FOR SPECIFIC FACILITIES WILL BE AUTHORIZED ONLY AFTER REVIEW AND CONCURRENCE OF A SAFETY FEATURES REVIEW COMMITTEE.

SAFETY FEATURES	REF. ST'DS	REMARKS
CIRCUIT DEVICES		
① MAIN DISCONNECT SWITCH	ES-1.9-14	INSTALL OUTSIDE VAULT, NEAR & IN SIGHT OF CONTROL PANEL.
② MILLIAMP & KILOVOLT METERS	ES-1.9-15	INTEGRAL WITH CONTROL CONSOLE.
③ SYSTEM ENERGIZING CONTACTOR	ES-1.9-16	MUST BREAK ALL X-RAY HIGH VOLTAGE TRANSFORMER ENERGIZING CONDUCTORS. IF OUTPUT IS 25 r/MIN./METER, TWO CONTACTORS (REDUNDANT) SHALL BE INSTALLED TO INDEPENDENTLY BREAK ALL HIGH VOLTAGE TRANSFORMER CONDUCTORS.
④ VOLTAGE-SENSING DEVICE	ES-1.9-17	INSTALL AS NEAR TO THE HIGH VOLTAGE TRANSFORMER AS PRACTICAL AND CONNECT DIRECTLY ACROSS THE PRIMARY LEADS OF THE TRANSFORMER.
⑦ VOLTAGE TIME DECAY CONTROL	ES-1.9-20	MUST DISCHARGE RESIDUAL X-RAY POWER SUPPLY VOLTAGE BEFORE PERSONNEL CAN ENTER VAULT.
INTERLOCKS		
⑧ ACCESS DOOR INTERLOCK	ES-1.9-22	ELECTRICALLY INTERLOCK ALL ACCESS DOORS.
⑬ SCRAM SWITCH INTERLOCK	ES-1.9-26	INSTALL INSIDE VAULT FOR EMERGENCY SHUTDOWN, TWO OR MORE SWITCHES SHOULD BE INSTALLED IN LARGE VAULTS.
VISUAL WARNING DEVICES		
⑳ SIGNS	ES-1.9-33	NUMBER, TYPE, AND LOCATION OF SIGNS FOR FACILITY ARE DETERMINED BY OPERATIONS AND RADIATION SAFETY DEPARTMENTS.
㉑ LINE ON LIGHT	ES-1.9-34	RED LIGHT, INSTALLED ON X-RAY CONTROL CONSOLE.
㉒ SYSTEM ON--STEADY LIGHT	ES-1.9-36	RED OR MAGENTA LIGHT, INSTALLED ON X-RAY CONTROL CONSOLE.
㉓ SYSTEM ON--FLASHING LIGHT	ES-1.9-37	RED OR MAGENTA LIGHTS, NUMBER & LOCATION DETERMINED BY OPERATIONS, RADIATION SAFETY, AND ENGINEERING DEPARTMENTS.
㉔ VSD ON/SOURCE EXPOSED--FL. LT.	ES-1.9-38	FLASHING LIGHTS RED OR MAGENTA.
AUDIBLE WARNING DEVICES		
㉕ BELL	ES-1.9-43	INSTALL INSIDE VAULT WHERE IT WILL BE AUDIBLE THROUGHOUT VAULT.

REQUIREMENTS CONT.

THE NEED FOR THE FOLLOWING SAFETY FEATURES ON EACH PARTICULAR X-RAY VAULT FACILITY WILL BE DETERMINED BY A SAFETY FEATURES REVIEW COMMITTEE. THESE ITEMS ARE NOTED BY AN "O" SYMBOL ON ES-1.9-2.

SAFETY FEATURES	REF. ST'DS	REMARKS
CIRCUIT DEVICES		
⑤ RADIATION MONITOR	ES-1.9-18	NUMBER, TYPE, AND LOCATION OF MONITORS ARE DETERMINED BY OPERATIONS AND RADIATION SAFETY DEPARTMENTS.
⑧ SOLENOID DOOR LOCKS	ES-1.9-19	PROVIDE MEANS FOR OVERRIDING DOOR LOCK FROM INSIDE VAULT.
INTERLOCKS		
⑪ RADIATION SHIELD INTERLOCK	ES-1.9-24	ALLOWS X-RAY OPERATION ONLY WHEN SHIELDS ARE IN PLACE
⑭ FORCED INSPECTION INTERLOCK	ES-1.9-27	INSTALL FORCED INSPECTION SWITCH SO THAT ENTIRE VAULT AREA MAY BE OBSERVED WHEN OPERATOR GOES TO AND FROM SWITCH LOCATION.
⑮ RADIATION BEAM POSITION INTLK.	ES-1.9-28	LIMITS OF PERMISSIBLE X-RAY BEAM LOCATION ARE DETERMINED BY OPERATIONS AND RADIATION SAFETY DEPARTMENTS.
⑯ LIGHT FAILURE INTERLOCK	ES-1.9-29	PREVENTS X-RAY OPERATION WHEN WARNING LIGHT IS INOPERATIVE.
⑰ KEY LOCKOUT INTERLOCK	ES-1.9-30	INSTALL ON OR NEAR X-RAY CONTROL CONSOLE.
⑱ FAIL STRIP INTERLOCK	ES-1.9-31	APPLY STRIP TO ALL SECTIONS OF VAULT ENCLOSURE THAT ARE SUBJECT TO UNINTENTIONAL BREAKAGE OR OPENING.
VISUAL WARNING DEVICES		
⑳ SYSTEM ARMED LIGHT	ES-1.9-35	AMBER LIGHT INSTALLED ON X-RAY CONSOLE.
㉔ X-RAY OFF/SOURCE SHIELDED LIGHT	ES-1.9-41	GREEN LIGHT INSTALLED ON X-RAY CONSOLE.
AUDIBLE WARNING DEVICES		
㉑ HORN	ES-1.9-44	INSTALL INSIDE VAULT WHERE IT WILL BE AUDIBLE THROUGHOUT VAULT.
PHYSICAL RESTRAINTS		
㉓ BARRICADES	ES-1.9-46	TYPE AND LOCATION OF BARRICADES ARE DETERMINED BY OPERATIONS, RADIATION SAFETY, AND ENGINEERING DEPARTMENTS.
㉔ PADLOCKS	ES-1.9-47	LOCATION OF PADLOCKS ARE DETERMINED BY OPERATIONS DEPARTMENT.

X-RAY ENCLOSED BEAM (TYPE 1A2)

ES-1.9-5

NOTE

1. NUMBERS IN CIRCLES REFER TO ITEMS LISTED ON PAGES 2 OF 3 AND 3 OF 3.

GENERAL

THIS STANDARD OUTLINES THE REQUIREMENTS FOR EQUIPPING X-RAY ENCLOSED BEAM FACILITIES WITH SAFETY DEVICES TO PROTECT PERSONNEL FROM HARMFUL IONIZING RADIATION.

REQUIREMENTS

IT IS REQUIRED THAT X-RAY ENCLOSED BEAM FACILITIES BE EQUIPPED WITH THE FOLLOWING SAFETY FEATURES. THESE ITEMS ARE NOTED BY AN "X" SYMBOL ON ES-1.9-2. EXCEPTIONS FOR SPECIFIC FACILITIES WILL BE AUTHORIZED ONLY AFTER REVIEW AND CONCURRENCE OF A SAFETY FEATURES REVIEW COMMITTEE.

SAFETY FEATURES	REF. ST'DS.	REMARKS
CIRCUIT DEVICES		
① MAIN DISCONNECT SWITCH	ES-1.9-14	INSTALL OUTSIDE X-RAY ENCLOSED BEAM FACILITY, NEAR & IN SIGHT OF CONTROL PANEL.
② MILLIAMP & KILOVOLT METERS	ES-1.9-15	INTEGRAL WITH CONTROL CONSOLE.
③ SYSTEM ENERGIZING CONTACTOR	ES-1.9-16	MUST BREAK ALL X-RAY HIGH VOLTAGE TRANSFORMER ENERGIZING CONDUCTORS. IF OUTPUT IS 25 R/MIN/METER, TWO CONTACTORS (REDUNDANT) SHALL BE INSTALLED TO INDEPENDENTLY BREAK ALL HIGH VOLTAGE TRANSFORMER CONDUCTORS.
④ VOLTAGE-SENSING DEVICE	ES-1.9-17	INSTALL AS NEAR TO THE HIGH VOLTAGE TRANSFORMER AS PRACTICAL AND CONNECT DIRECTLY ACROSS THE PRIMARY LEADS OF THE TRANSFORMER.
⑦ VOLTAGE TIME DECAY CONTROL	ES-1.9-20	MUST DISCHARGE RESIDUAL X-RAY POWER SUPPLY VOLTAGE BEFORE PERSONNEL CAN ENTER ENCLOSURE.
INTERLOCKS		
⑩ ENCLOSURE PANEL INTERLOCK	ES-1.9-23	ELECTRICAL INTERLOCK
VISUAL WARNING DEVICES		
⑳ SIGNS	ES-1.9-33	NUMBER, TYPE, AND LOCATION OF SIGNS FOR FACILITY ARE DETERMINED BY OPERATIONS AND RADIATION SAFETY DEPARTMENTS.
㉑ LINE ON LIGHT	ES-1.9-34	RED LIGHT, INSTALLED ON X-RAY CONTROL PANEL.
㉒ SYSTEM ON--STEADY LIGHT	ES-1.9-36	RED OR MAGENTA, INSTALLED ON X-RAY CONTROL PANEL.
㉓ SYSTEM ON--FLASHING LIGHT	ES-1.9-37	RED OR MAGENTA, NUMBER & LOCATION DETERMINED BY OPERATIONS, RADIATION SAFETY, AND ENGINEERING DEPARTMENTS.
㉔ VSD ON/SOURCE EXPOSED--FL. LT.	ES-1.9-38	FLASHING LIGHTS, RED OR MAGENTA.
AUDIBLE WARNING DEVICES		
PHYSICAL RESTRAINTS		

REQUIREMENTS CONT.

THE NEED FOR THE FOLLOWING SAFETY FEATURES ON EACH PARTICULAR X-RAY ENCLOSED BEAM FACILITY WILL BE DETERMINED BY A SAFETY FEATURES REVIEW COMMITTEE. THESE ITEMS ARE NOTED BY AN "O" SYMBOL ON ES-1.9-2.

SAFETY FEATURES	REF. ST'DS.	REMARKS
CIRCUIT DEVICES		
INTERLOCKS		
⑨ ACCESS DOOR INTERLOCK	ES-1.9-22	ELECTRICALLY INTERLOCK ALL ACCESS DOORS.
④ RADIATION SHIELD INTERLOCK	ES-1.9-24	ELECTRICAL INTERLOCK.
⑫ BARRICADE INTERLOCK	ES-1.9-25	ELECTRICAL INTERLOCK.
⑮ RADIATION BEAM POSITION INTERLOCK	ES-1.9-28	LIMITS OF PERMISSIBLE X-RAY BEAM LOCATION ARE DETERMINED BY OPERATIONS AND RADIATION SAFETY DEPARTMENTS.
⑮ LIGHT FAILURE INTERLOCK	ES-1.9-29	PREVENTS X-RAY OPERATION WHEN WARNING LIGHT IS INOPERATIVE.
⑰ KEY LOCK-OUT INTERLOCK	ES-1.9-30	INSTALLED ON OR NEAR X-RAY CONTROL CONSOLE.
VISUAL WARNING DEVICES		
⑳ SYSTEM ARMED LIGHT	ES-1.9-35	AMBER LIGHT INSTALLED ON X-RAY CONTROL CONSOLE.
㉔ X-RAY OFF/SOURCE SHIELDED LIGHT	ES-1.9-41	GREEN LIGHT INSTALLED ON X-RAY CONTROL CONSOLE.
AUDIBLE WARNING DEVICES		
PHYSICAL RESTRAINTS		
㉓ BARRICADES	ES-1.9-46	TYPE AND LOCATION OF BARRICADES ARE DETERMINED BY OPERATIONS, RADIATION SAFETY, AND ENGINEERING DEPARTMENTS.
㉔ PADLOCKS	ES-1.9-47	LOCATION OF PADLOCKS ARE DETERMINED BY OPERATIONS DEPARTMENT.

X-RAY OPEN BEAM (TYPE 1A3)

ES-1.9-6

NOTE

1. NUMBERS IN CIRCLES REFER TO ITEMS LISTED ON PAGES 2 OF 3 AND 3 OF 3.
2. DISCONNECT SWITCH AND CONTROL PANEL SHOULD BE MOUNTED ON UNISTRUT RACKING ADJACENT TO ENCLOSURE.

GENERAL

THIS STANDARD OUTLINES THE REQUIREMENTS FOR EQUIPPING X-RAY OPEN BEAM FACILITIES WITH SAFETY DEVICES TO PROTECT PERSONNEL FROM HARMFUL IONIZING RADIATION.

REQUIREMENTS

IT IS REQUIRED THAT X-RAY OPEN BEAM FACILITIES BE EQUIPPED WITH THE FOLLOWING SAFETY FEATURES. THESE ITEMS ARE NOTED BY AN "X" SYMBOL ON ES-1.9-2. EXCEPTIONS FOR SPECIFIC FACILITIES WILL BE AUTHORIZED ONLY AFTER REVIEW AND CONCURRENCE OF A SAFETY FEATURES REVIEW COMMITTEE.

SAFETY FEATURES	REF. ST'DS.	REMARKS
CIRCUIT DEVICES		
(1) MAIN DISCONNECT SWITCH	ES-1.9-14	INSTALL OUTSIDE VAULT, NEAR & IN SIGHT OF CONTROL PANEL.
(2) MILLIAMPERE & KILOVOLT METERS	ES-1.9-15	INTEGRAL WITH CONTROL CONSOLE.
(3) SYSTEM ENERGIZING CONTACTOR	ES-1.9-16	MUST BREAK ALL X-RAY HIGH VOLTAGE TRANSFORMER ENERGIZING CONDUCTORS. IF OUTPUT IS 25 R/MIN./METER, TWO CONTACTORS (REDUNDANT) SHALL BE INSTALLED TO INDEPENDENTLY BREAK ALL HIGH VOLTAGE TRANSFORMER CONDUCTORS.
(4) VOLTAGE-SENSING DEVICE	ES-1.9-17	INSTALL AS NEAR TO THE HIGH VOLTAGE TRANSFORMER AS PRACTICAL AND CONNECT DIRECTLY ACROSS THE PRIMARY LEADS OF THE TRANSFORMER.
(7) VOLTAGE TIME DECAY CONTROL	ES-1.9-20	MUST DISCHARGE RESIDUAL X-RAY POWER SUPPLY VOLTAGE BEFORE PERSONNEL CAN REMOVE X-RAY ENCLOSURE PANELS.
INTERLOCKS		
(10) ENCLOSURE PANELS INTERLOCK	ES-1.9-23	ELECTRICALLY INTERLOCK ALL ENCLOSURE PANELS.
VISUAL WARNING DEVICES		
(20) SIGNS	ES-1.9-33	NUMBER, TYPE, AND LOCATION OF SIGNS FOR FACILITY ARE DETERMINED BY OPERATIONS AND RADIATION SAFETY DEPARTMENTS.
(21) LINE ON LIGHT	ES-1.9-34	RED LIGHT, INSTALLED ON X-RAY CONTROL CONSOLE.
(23) SYSTEM ON--STEADY LIGHT	ES-1.9-36	RED OR MAGENTA LIGHT, INSTALLED ON X-RAY CONTROL CONSOLE.
(24) SYSTEM ON--FLASHING LIGHT	ES-1.9-37	RED OR MAGENTA LIGHT, NUMBER & LOCATION DETERMINED BY OPERATIONS, RADIATION SAFETY, AND ENGINEERING DEPARTMENTS.
(25) VSD ON/SOURCE EXPOSED--FL. LT.	ES-1.9-38	FLASHING LIGHTS RED OR MAGENTA.
PHYSICAL RESTRAINTS		
(33) BARRICADES	ES-1.9-46	TYPES OF BARRICADES ARE DETERMINED BY OPERATIONS, RADIATION SAFETY, AND ENGINEERING DEPARTMENTS.

REQUIREMENTS CONT.

THE NEED FOR THE FOLLOWING SAFETY FEATURES ON EACH PARTICULAR OPEN BEAM FACILITY WILL BE DETERMINED BY A SAFETY FEATURES REVIEW COMMITTEE. THESE ITEMS ARE NOTED BY AN "Q" SYMBOL ON ES-1.9-2.

SAFETY FEATURES.	REF. ST'DS.	REMARKS
INTERLOCKS		
(9) ACCESS DOOR INTERLOCK	ES-1.9-22	ELECTRICAL INTERLOCK
(11) RADIATION SHIELD INTERLOCK	ES-1.9-24	ELECTRICAL INTERLOCK
(12) BARRICADE INTERLOCK	ES-1.9-25	ELECTRICAL INTERLOCK
(13) SCRAM SWITCH INTERLOCK	ES-1.9-26	EMERGENCY SHUTDOWN
(15) RADIATION BEAM POSITION INTERLOCK	ES-1.9-28	ELECTRICAL INTERLOCK
(16) LIGHT FAILURE INTERLOCK	ES-1.9-29	PREVENTS X-RAY OPERATION WHEN WARNING LIGHT IS INOPERATIVE
(17) KEY LOCKOUT INTERLOCK	ES-1.9-30	INSTALL ON OR NEAR X-RAY CONTROL CONSOLE
VISUAL WARNING DEVICES		
(22) SYSTEM ARMED LIGHT	ES-1.9-35	AMBER LIGHT INSTALLED ON X-RAY CONTROL PANEL
(26) SHUTTER OPEN--FLASHING LIGHT	ES-1.9-39	RED OR MAGENTA LIGHT
(27) SHUTTER CLOSED--STEADY LIGHT	ES-1.9-40	GREEN LIGHT INSTALLED ON X-RAY CONTROL PANEL
(28) X-RAY OFF/SOURCE SHIELDED LIGHT	ES-1.9-41	GREEN LIGHT INSTALLED ON X-RAY CONTROL PANEL
AUDIBLE WARNING DEVICES		
(31) HORN	ES-1.9-44	INSTALL INSIDE ROOM
PHYSICAL RESTRAINTS		
(34) PADLOCKS	ES-1.9-47	LOCATION OF PADLOCKS ARE DETERMINED BY OPERATIONS DEPARTMENT

X-RAY STORAGE FACILITIES (TYPE IB)

ES-1.9-7

NOTE

1. NUMBERS IN CIRCLES REFER TO ITEMS LISTED ON MATRIX ES-1.9-2.

RADIOACTIVE SOURCE VAULT (TYPE IIA1)

ES-1.9-8

NOTES

1. FOR DESCRIPTION OF ITEMS, SEE SHEET #2.
2. HOLES IN BARRIERS FOR PIPES, DUCTS, CONDUITS, ETC. SHALL BE PROVIDED WITH BAFFLES TO INSURE THAT THE OVERALL PROTECTION AFFORDED BY THE BARRIER IS NOT IMPAIRED.
3. NUMBERS IN CIRCLES REFER TO ITEMS LISTED ON PAGES 2 OF 3 AND 3 OF 3.

GENERAL

THIS STANDARD OUTLINES THE REQUIREMENTS FOR EQUIPPING RADIOACTIVE SOURCE VAULT FACILITIES WITH SAFETY DEVICES TO PROTECT PERSONNEL FROM HARMFUL IONIZING RADIATION.

REQUIREMENTS

IT IS REQUIRED THAT RADIOACTIVE SOURCE VAULT FACILITIES BE EQUIPPED WITH THE FOLLOWING SAFETY FEATURES. THESE ITEMS ARE NOTED BY AN "X" SYMBOL ON ES-1.9-2. EXCEPTIONS FOR SPECIFIC FACILITIES WILL BE AUTHORIZED ONLY AFTER REVIEW AND CONCURRENCE OF A SAFETY FEATURES REVIEW COMMITTEE.

SAFETY FEATURES	REF. ST'DS.	REMARKS
CIRCUIT DEVICES		
(1) MAIN DISCONNECT SWITCH	ES-1.9-14	INSTALL OUTSIDE VAULT, NEAR & IN SIGHT OF CONTROL PANEL.
(5) RADIATION MONITOR	ES-1.9-18	NUMBER, TYPE, AND LOCATION OF MONITORS ARE DETERMINED BY OPERATIONS AND RADIATION SAFETY DEPARTMENTS.
(6) SOLENOID DOOR LOCKS	ES-1.9-19	PROVIDE MEANS FOR OVERRIDING DOOR LOCK FROM INSIDE VAULT.
INTERLOCKS		
(9) ACCESS DOOR INTERLOCK	ES-1.9-22	ELECTRICALLY INTERLOCK ALL ACCESS DOORS.
(11) RADIATION SHIELD INTERLOCK	ES-1.9-24	ELECTRICAL INTERLOCK
(13) SCRAM SWITCH INTERLOCK	ES-1.9-26	INSTALL INSIDE VAULT FOR EMERGENCY SHUTDOWN. TWO OR MORE SWITCHES SHOULD BE INSTALLED IN LARGE VAULTS.
VISUAL WARNING DEVICES		
(20) SIGNS	ES-1.9-33	NUMBER, TYPE, AND LOCATION OF SIGNS FOR FACILITY ARE DETERMINED BY OPERATIONS AND RADIATION SAFETY DEPARTMENTS.
(21) LINE ON LIGHT	ES-1.9-34	RED LIGHT, INSTALLED ON CONTROL CONSOLE.
(23) SYSTEM ON--STEADY LIGHT	ES-1.9-36	RED OR MAGENTA, INSTALLED ON CONTROL CONSOLE.
(24) SYSTEM ON--FLASHING LIGHT	ES-1.9-37	RED OR MAGENTA, NUMBER & LOCATION DETERMINED BY OPERATIONS, RADIATION SAFETY, AND ENGINEERING DEPARTMENTS.
(25) VSD ON/SOURCE EXPOSED--FL. LT.	ES-1.9-38	FLASHING LIGHTS, RED OR MAGENTA.
(28) X-RAY OFF/SOURCE SHIELDED LIGHT	ES-1.9-41	GREEN LIGHT INSTALLED ON CONTROL CONSOLE.
AUDIBLE WARNING DEVICES		
(30) BELL	ES-1.9-43	INSTALL INSIDE VAULT WHERE IT WILL BE AUDIBLE THROUGHOUT VAULT.

REQUIREMENTS CONT.

THE NEED FOR THE FOLLOWING SAFETY FEATURES ON EACH PARTICULAR RADIOACTIVE SOURCE VAULT FACILITY WILL BE DETERMINED BY A SAFETY FEATURES REVIEW COMMITTEE. THESE ITEMS ARE NOTED BY AN "O" SYMBOL ON ES-1.9-2.

SAFETY FEATURES	REF. ST'DS.	REMARKS
CIRCUIT DEVICES		
(3) SYSTEM ENERGIZING CONTACTOR	ES-1.9-16	BREAKS ALL SOURCE DRIVE CONDUCTORS. REQUIRED ON ALL SYSTEMS THAT ARE ELECTRICALLY ACTUATED.
INTERLOCK		
(14) FORCED INSPECTION INTERLOCK	ES-1.9-27	INSTALL FORCED INSPECTION SWITCH SO THAT ENTIRE VAULT AREA MAY BE OBSERVED WHEN OPERATOR GOES TO AND FROM SWITCH LOCATION.
(15) RADIATION BEAM POSITION INTLK.	ES-1.9-28	LIMITS OF PERMISSIBLE RADIOACTIVE SOURCE BEAM LOCATION ARE DETERMINED BY OPERATIONS AND RADIATION SAFETY DEPARTMENTS.
(16) LIGHT FAILURE INTERLOCK	ES-1.9-29	PREVENTS RADIOACTIVE SOURCE OPERATION WHEN WARNING LIGHT IS INOPERATIVE.
(17) KEY LOCK-OUT INTERLOCK	ES-1.9-30	INSTALL ON OR NEAR CONTROL CONSOLE.
(18) FAIL STRIP INTERLOCK	ES-1.9-31	APPLY STRIP TO ALL SECTIONS OF VAULT ENCLOSURE THAT ARE SUBJECT TO UNINTENTIONAL BREAKAGE OR OPENING.
VISUAL WARNING DEVICES		
(22) SYSTEM ARMED LIGHT	ES-1.9-35	AMBER LIGHT INSTALLED ON CONTROL CONSOLE.
AUDIBLE WARNING DEVICES		
(31) HORN	ES-1.9-44	INSTALL INSIDE VAULT WHERE IT WILL BE AUDIBLE THROUGHOUT VAULT.
PHYSICAL RESTRAINTS		
(33) BARRICADES	ES-1.9-46	TYPE AND LOCATION OF BARRICADES ARE DETERMINED BY OPERATIONS, RADIATION SAFETY, AND ENGINEERING DEPARTMENTS.
(34) PADLOCKS	ES-1.9-47	LOCATION OF PADLOCKS ARE DETERMINED BY OPERATIONS DEPARTMENT.

RADIOACTIVE SOURCE ENCLOSED BEAM (TYPE IIA2)

ES-1.9-9

NOTE

1. NUMBERS IN CIRCLES REFER TO ITEMS LISTED ON PAGE 2 OF 2.

GENERAL

THIS STANDARD OUTLINES THE REQUIREMENTS FOR EQUIPPING RADIOACTIVE SOURCE ENCLOSED BEAM FACILITIES WITH SAFETY DEVICES TO PROTECT PERSONNEL FROM HARMFUL IONIZING RADIATION.

REQUIREMENTS

IT IS REQUIRED THAT RADIOACTIVE SOURCE ENCLOSED BEAM FACILITIES BE EQUIPPED WITH THE FOLLOWING SAFETY FEATURE. THIS FEATURE IS NOTED BY AN "X" SYMBOL ON ES-1.9-2. EXCEPTIONS FOR SPECIFIC FACILITIES WILL BE AUTHORIZED ONLY AFTER REVIEW AND CONCURRENCE OF A SAFETY FEATURES REVIEW COMMITTEE.

SAFETY FEATURES	REF. ST'DS.	REMARKS
VISUAL WARNING DEVICES		
(20) SIGNS	ES-1.9-33	NUMBER, TYPE, AND LOCATION OF SIGNS FOR FACILITY ARE DETERMINED BY OPERATIONS AND RADIATION SAFETY DEPARTMENTS.

THE NEED FOR THE FOLLOWING SAFETY FEATURES ON EACH PARTICULAR RADIOACTIVE SOURCE ENCLOSED BEAM FACILITY WILL BE DETERMINED BY A SAFETY FEATURES REVIEW COMMITTEE. THESE ITEMS ARE NOTED BY AN "O" SYMBOL ON ES-1.9-2.

SAFETY FEATURES	REF. ST'DS.	REMARKS
CIRCUIT DEVICES		
(1) MAIN DISCONNECT SWITCH	ES-1.9-14	INSTALL NEAR AND IN SIGHT OF CONTROL PANEL.
(3) SYSTEM ENERGIZING CONTACTOR	ES-1.9-16	REQUIRED ON ALL ELECTRICALLY ACTUATED SYSTEMS.
(5) RADIATION MONITOR	ES-1.9-18	NUMBER, TYPE, AND LOCATION OF MONITORS ARE DETERMINED BY OPERATIONS AND RADIATION SAFETY DEPARTMENTS.
INTERLOCKS		
(9) ACCESS DOOR INTERLOCK	ES-1.9-22	ELECTRICALLY INTERLOCK ALL ACCESS DOORS
(10) ENCLOSURE PANEL INTERLOCK	ES-1.9-23	ELECTRICAL INTERLOCK
(11) RADIATION SHIELD INTERLOCK	ES-1.9-24	ELECTRICAL INTERLOCK
(12) BARRICADE INTERLOCK	ES-1.9-25	ELECTRICAL INTERLOCK
(15) RADIATION BEAM POSITION INTERLOCK	ES-1.9-28	LIMITS OF PERMISSIBLE RADIOACTIVE SOURCE ENCLOSED BEAM LOCATION ARE DETERMINED BY OPERATIONS AND RADIATION SAFETY DEPARTMENTS.
(16) LIGHT FAILURE INTERLOCK	ES-1.9-29	PREVENTS RADIOACTIVE SOURCE OPERATION WHEN WARNING LIGHT IS INOPERATIVE.
(17) KEY LOCK-OUT INTERLOCK	ES-1.9-30	INSTALL ON OR NEAR RADIOACTIVE SOURCE CONTROL CONSOLE.
VISUAL WARNING DEVICES		
(21) LINE ON LIGHT	ES-1.9-34	RED LIGHT, INSTALLED ON RADIOACTIVE SOURCE CONTROL CONSOLE.
(22) SYSTEM ARMED LIGHT	ES-1.9-35	AMBER LIGHT INSTALLED ON RADIOACTIVE SOURCE CONTROL CONSOLE.
(23) SYSTEM ON--STEADY LIGHT	ES-1.9-36	RED OR MAGENTA LIGHT, INSTALLED ON RADIOACTIVE SOURCE CONTROL CONSOLE.
(24) SYSTEM ON--FLASHING LIGHT	ES-1.9-37	RED OR MAGENTA LIGHTS, NUMBER AND LOCATION DETERMINED BY OPERATIONS, RADIATION SAFETY, AND ENGINEERING DEPARTMENTS.
(25) VSD ON/SOURCE EXPOSED--FL. LT.	ES-1.9-38	FLASHING LIGHTS, RED OR MAGENTA.
(26) X-RAY OFF/SOURCE SHIELDED LIGHT	ES-1.9-41	GREEN LIGHT INSTALLED ON RADIOACTIVE SOURCE CONTROL CONSOLE.
PHYSICAL RESTRAINTS		
(33) BARRICADES	ES-1.9-46	TYPE AND LOCATION OF BARRICADES ARE DETERMINED BY OPERATIONS, RADIATION SAFETY, AND ENGINEERING DEPARTMENTS.
(34) PADLOCKS	ES-1.9-47	LOCATION OF PADLOCKS ARE DETERMINED BY OPERATIONS DEPARTMENT.

RADIOACTIVE SOURCE OPEN BEAM (TYPE IIA3)

ES-1.9-10

NOTE

1. NUMBERS IN CIRCLES REFER TO ITEMS LISTED ON PAGES 2 OF 3 AND 3 OF 3.
2. DISCONNECT SWITCH AND CONTROL PANEL SHOULD BE MOUNTED ON UNISTRUT RACKING ADJACENT TO ENCLOSURE.

GENERAL

THIS STANDARD OUTLINES THE REQUIREMENTS FOR EQUIPPING RADIOACTIVE SOURCE OPEN BEAM FACILITIES WITH SAFETY DEVICES TO PROTECT PERSONNEL FROM HARMFUL IONIZING RADIATION.

REQUIREMENTS

IT IS REQUIRED THAT RADIOACTIVE SOURCE OPEN BEAM FACILITIES BE EQUIPPED WITH THE FOLLOWING SAFETY FEATURES: THESE ITEMS ARE NOTED BY AN "X" SYMBOL ON ES-1.9-2. EXCEPTIONS FOR SPECIFIC FACILITIES WILL BE AUTHORIZED ONLY AFTER REVIEW AND CONCURRENCE OF A SAFETY FEATURES REVIEW COMMITTEE.

SAFETY FEATURES	REF. ST'DS.	REMARKS
CIRCUIT DEVICES		
INTERLOCKS		
VISUAL WARNING DEVICES		
(20) SIGNS	ES-1.9-33	NUMBER, TYPE, AND LOCATION OF SIGNS FOR FACILITY ARE DETERMINED BY OPERATIONS AND RADIATION SAFETY DEPARTMENTS.
AUDIBLE WARNING DEVICES		
PHYSICAL RESTRAINTS		
(33) BARRICADES	ES-1.9-46	TYPE AND LOCATION OF BARRICADES ARE DETERMINED BY OPERATIONS, RADIATION SAFETY, AND ENGINEERING DEPARTMENTS.

REQUIREMENTS CONT.

THE NEED FOR THE FOLLOWING SAFETY FEATURES ON EACH PARTICULAR RADIOACTIVE SOURCE OPEN BEAM FACILITY WILL BE DETERMINED BY A SAFETY FEATURES REVIEW COMMITTEE. THESE ITEMS ARE NOTED BY AN "O" SYMBOL ON ES-1.9-2.

SAFETY FEATURES	REF. ST'DS.	REMARKS
CIRCUIT DEVICES		
① MAIN DISCONNECT SWITCH	ES-1.9-14	INSTALL NEAR & IN SIGHT OF CONTROL PANEL
③ SYSTEM ENERGIZING CONTACTOR	ES-1.9-16	BREAKS ALL SOURCE DRIVE MOTOR POWER CONDUCTORS. REQUIRED ON ALL ELECTRICALLY ACTUATED SYSTEMS.
⑤ RADIATION MONITOR	ES-1.9-18	NUMBER, TYPE, AND LOCATION OF MONITORS ARE DETERMINED BY OPERATIONS AND RADIATION SAFETY DEPARTMENTS.
INTERLOCKS		
⑨ ACCESS DOOR INTERLOCK	ES-1.9-22	ELECTRICALLY INTERLOCK ALL ACCESS DOORS.
⑩ ENCLOSURE PANELS INTERLOCK	ES-1.9-23	ELECTRICAL INTERLOCK
⑪ RADIATION SHIELD INTERLOCK	ES-1.9-24	ELECTRICAL INTERLOCK
⑫ BARRICADE INTERLOCK	ES-1.9-25	ELECTRICAL INTERLOCK
⑮ RADIATION BEAM POSITION INTERLOCK	ES-1.9-28	LIMITS OF PERMISSIBLE BEAM LOCATION ARE DETERMINED BY OPERATIONS AND RADIATION SAFETY DEPARTMENT.
⑯ LIGHT FAILURE INTERLOCK	ES-1.9-29	PREVENTS OPERATION WHEN WARNING LIGHT IS INOPERATIVE.
⑰ KEY LOCK OUT INTERLOCK	ES-1.9-30	INSTALL ON OR NEAR CONTROL CONSOLE.
VISUAL WARNING DEVICES		
⑰ LINE ON LIGHT	ES-1.9-34	RED LIGHT, INSTALLED ON CONTROL CONSOLE.
⑳ SYSTEM ARMED LIGHT	ES-1.9-35	AMBER LIGHT, INSTALLED ON CONTROL CONSOLE.
㉑ SYSTEM ON--STEADY LIGHT	ES-1.9-36	RED OR MAGENTA, INSTALLED ON CONTROL CONSOLE.
㉒ SYSTEM ON--FLASHING LIGHT	ES-1.9-37	RED OR MAGENTA, NUMBER & LOCATION DETERMINED BY OPERATIONS, RADIATION SAFETY, AND ENGINEERING DEPARTMENTS.
㉓ VSD ON/SOURCE EXPOSED--FL. LT.	ES-1.9-38	FLASHING LIGHTS, RED OR MAGENTA
㉔ SHUTTER OPEN--FLASHING LIGHT	ES-1.9-39	RED OR MAGENTA.
㉕ SHUTTER CLOSED--STEADY LIGHT	ES-1.9-40	GREEN LIGHT INSTALLED ON CONTROL CONSOLE.
㉖ X-RAY OFF/SOURCE SHIELDED LIGHT	ES-1.9-41	GREEN LIGHT INSTALLED ON CONTROL CONSOLE.
AUDIBLE WARNING DEVICES		
⑳ HORN	ES-1.9-44	INSTALL INSIDE RADIOACTIVE SOURCE OPEN BEAM FACILITY WHERE IT WILL BE AUDIBLE THROUGHOUT RADIOACTIVE SOURCE OPEN BEAM FACILITY.
PHYSICAL RESTRAINTS		
㉗ PADLOCKS	ES-1.9-47	LOCATION OF PADLOCKS ARE DETERMINED BY OPERATIONS DEPARTMENT.

RADIOACTIVE SOURCE STORAGE FACILITY (TYPE IIB)

ES-1.9-11

NOTE

1. NUMBERS IN CIRCLES REFER TO ITEMS LISTED ON PAGE 2 OF 2.

GENERAL

THIS STANDARD OUTLINES THE REQUIREMENTS FOR EQUIPPING RADIOACTIVE SOURCE STORAGE FACILITIES WITH SAFETY DEVICES TO PROTECT PERSONNEL FROM HARMFUL IONIZING RADIATION.

REQUIREMENTS

IT IS REQUIRED THAT RADIOACTIVE SOURCE STORAGE FACILITIES BE EQUIPPED WITH THE FOLLOWING SAFETY FEATURES. THESE ITEMS ARE NOTED BY AN "X" SYMBOL ON ES-1.9-2. EXCEPTIONS FOR SPECIFIC FACILITIES WILL BE AUTHORIZED ONLY AFTER REVIEW AND CONCURRENCE OF A SAFETY FEATURES REVIEW COMMITTEE.

SAFETY FEATURES	REF. ST'DS.	REMARKS
VISUAL WARNING DEVICES		
(20) SIGNS	ES-1.9-33	NUMBER, TYPE, AND LOCATION OF SIGNS FOR FACILITY ARE DETERMINED BY OPERATIONS AND RADIATION SAFETY DEPARTMENTS.
PHYSICAL RESTRAINTS		
(34) PADLOCKS	ES-1.9-47	LOCATION OF PADLOCKS ARE DETERMINED BY OPERATIONS DEPARTMENT.

THE NEED FOR THE FOLLOWING SAFETY FEATURES ON EACH PARTICULAR RADIOACTIVE SOURCE STORAGE FACILITY WILL BE DETERMINED BY A SAFETY FEATURES REVIEW COMMITTEE. THESE ITEMS ARE NOTED BY AN "O" SYMBOL ON ES-1.9-2.

SAFETY FEATURES	REF. ST'DS.	REMARKS
CIRCUIT DEVICES		
(5) RADIATION MONITOR	ES-1.9-18	NUMBER, TYPE, AND LOCATION OF MONITORS ARE DETERMINED BY OPERATIONS AND RADIATION SAFETY DEPARTMENTS.
(6) SOLENOID DOOR LOCKS	ES-1.9-19	PROVIDE MEANS FOR OVERRIDING DOOR LOCKS FROM INSIDE FACILITY.
PHYSICAL RESTRAINTS		
(33) BARRICADES	ES-1.9-46	TYPE AND LOCATION OF BARRICADES ARE DETERMINED BY OPERATIONS, RADIATION SAFETY, AND ENGINEERING DEPARTMENTS.

RADIOACTIVE SOURCES LESS THAN 50 MILLI-CURIES (TYPE IIC)

ES-1.9-12

NOTE

1. NUMBERS IN CIRCLES REFER TO ITEMS LISTED ON ES-1.9-2.

NONVACUUM E. B. WELDER (TYPE IIIA)

ES-1.9-13

NOTE

1. NUMBERS IN CIRCLES REFER TO ITEMS LISTED ON PAGES 2 OF 2 AND 2 OF 3.

GENERAL

THIS STANDARD OUTLINES THE REQUIREMENTS FOR EQUIPPING NON VACUUM ELECTRON BEAM WELDING FACILITIES WITH SAFETY DEVICES TO PROTECT PERSONNEL FROM HARMFUL IONIZING RADIATION.

REQUIREMENTS

IT IS REQUIRED THAT NON VACUUM ELECTRON BEAM WELDING FACILITIES BE EQUIPPED WITH THE FOLLOWING SAFETY FEATURES. THESE ITEMS ARE NOTED BY AN "X" SYMBOL ON ES-1.9-2. EXCEPTIONS FOR SPECIFIC FACILITIES WILL BE AUTHORIZED ONLY AFTER REVIEW AND CONCURRENCE OF A SAFETY FEATURES REVIEW COMMITTEE.

SAFETY FEATURES	REF. ST'DS.	REMARKS
CIRCUIT DEVICES		
(1) MAIN DISCONNECT SWITCH	ES-1.9-14	INSTALL NEAR & IN SIGHT OF CONTROL PANEL.
(2) MILLIAMPER & KILOVOLT METERS	ES-1.9-15	INTEGRAL WITH CONTROL CONSOLE.
(3) SYSTEM ENERGIZING CONTACTOR	ES-1.9-16	MUST BREAK ALL HIGH VOLTAGE TRANSFORMER ENERGIZING CONDUCTORS. IF OUTPUT IS 25R /MIN./METER, TWO CONTACTORS (REDUNDANT) SHALL BE INSTALLED TO INDEPENDENTLY BREAK ALL HIGH VOLTAGE TRANSFORMER CONDUCTORS.
(4) VOLTAGE-SENSING DEVICE	ES-1.9-17	INSTALL AS NEAR TO THE HIGH VOLTAGE TRANSFORMER AS PRACTICAL AND CONNECT DIRECTLY ACROSS THE PRIMARY LEADS OF THE TRANSFORMER.
(7) VOLTAGE TIME DECAY CONTROL	ES-1.9-20	MUST DISCHARGE RESIDUAL X-RAY POWER SUPPLY VOLTAGE BEFORE PERSONNEL CAN ENTER ENCLOSURE.
INTERLOCKS		
(9) ACCESS DOOR INTERLOCK	ES-1.9-22	ELECTRICALLY INTERLOCK ALL ACCESS DOORS.
VISUAL WARNING DEVICES		
(20) SIGNS	ES-1.9-33	NUMBER, TYPE, AND LOCATION OF SIGNS FOR FACILITY ARE DETERMINED BY OPERATIONS AND RADIATION SAFETY DEPARTMENTS.
(21) LINE ON LIGHT	ES-1.9-34	RED LIGHT, INSTALLED ON CONTROL PANEL.
(23) SYSTEM ON--STEADY LIGHT	ES-1.9-36	RED OR MAGENTA, INSTALLED ON CONTROL PANEL.
(24) SYSTEM ON--FLASHING LIGHT	ES-1.9-37	RED OR MAGENTA, NUMBER & LOCATION DETERMINED BY OPERATIONS, RADIATION SAFETY, AND ENGINEERING DEPARTMENTS.
(25) VSD ON/SOURCE EXPOSED--FL. LT.	ES-1.9-38	FLASHING LIGHTS, RED OR MAGENTA.
AUDIBLE WARNING DEVICES		
(30) BELL	ES-1.9-43	INSTALL ON CONTROL PANEL.

REQUIREMENTS CONT.

THE NEED FOR THE FOLLOWING SAFETY FEATURES ON EACH PARTICULAR NON VACUUM ELECTRON BEAM WELDING FACILITY WILL BE DETERMINED BY A SAFETY FEATURES REVIEW COMMITTEE. THESE ITEMS ARE NOTED BY AN "O" SYMBOL ON ES-1.9-2.

SAFETY FEATURES	REF. ST'DS.	REMARKS
CIRCUIT DEVICES		
(5) RADIATION MONITOR	ES-1.9-18	NUMBER, TYPE, AND LOCATION OF MONITORS ARE DETERMINED BY OPERATIONS AND RADIATION SAFETY DEPARTMENTS.
(6) SOLENOID DOOR LOCKS	ES-1.9-19	PROVIDE MEANS FOR OVERRIDING DOOR LOCK FROM INSIDE VAULT
INTERLOCKS		
(10) ENCLOSURE PANELS INTERLOCK	ES-1.9-23	ELECTRICALLY INTERLOCK ALL ENCLOSURE PANELS.
(11) RADIATION SHIELD INTERLOCK	ES-1.9-24	ELECTRICAL INTERLOCK
(13) SCRAM SWITCH INTERLOCK	ES-1.9-26	EMERGENCY SHUTDOWN SWITCH LOCATED ON CONTROL PANEL.
(14) FORCED INSPECTION INTERLOCK	ES-1.9-27	INSTALL FORCED INSPECTION SWITCH SO THAT ENTIRE VAULT AREA MAY BE OBSERVED WHEN OPERATOR GOES TO AND FROM SWITCH LOCATION.
(16) LIGHT FAILURE INTERLOCK	ES-1.9-28	PREVENTS WELDER OPERATION WHEN WARNING LIGHT IS INOPERATIVE
(17) KEY LOCKOUT INTERLOCK	ES-1.9-30	INSTALL ON CONTROL PANEL
VISUAL WARNING DEVICES		
(28) X-RAY OFF/SOURCE SHIELDED LT.	ES-1.9-41	GREEN LIGHT INSTALLED ON CONTROL PANEL.
AUDIBLE WARNING DEVICES		
(31) HORN	ES-1.9-44	INSTALL ON CONTROL PANEL.
PHYSICAL RESTRAINTS		
(33) BARRICADES	ES-1.9-46	TYPE AND LOCATION OF BARRICADES ARE DETERMINED BY OPERATIONS, RADIATION SAFETY, AND ENGINEERING DEPARTMENTS.
(34) PADLOCKS	ES-1.9-47	LOCATION OF PADLOCKS ARE DETERMINED BY OPERATIONS DEPARTMENT.

1 MAIN DISCONNECT SWITCH

ES-1.9-14

GENERAL

A MAIN DISCONNECT SWITCH IS AN ELECTRICAL SAFETY SWITCH OR OTHER MANUALLY-OPERATED DEVICE TO BREAK ALL INPUT POWER (HOT) CONDUCTORS TO A RADIATION-PRODUCING SYSTEM. THIS SAFETY FEATURE IS REQUIRED ON ALL ELECTRICAL SYSTEMS.

THE SWITCH SHALL BE LOCATED SO AS TO BE READILY ACCESSIBLE FROM THE SYSTEM CONTROL PANEL OR CONSOLE. IF AUXILIARY POWER SOURCES ARE REQUIRED, THEY SHALL BE DE-ENERGIZED THROUGH USE OF AUXILIARY CONTACTS ON THE MAIN SWITCH.

IN CASES WHERE PORTABLE UNITS WITH POWER CORDS PLUG INTO A RECEPTACLE, THE PLUG CAN BE USED AS THE MAIN DISCONNECT.

DESCRIPTION

SAFETY SWITCHES THAT COMPLY WITH REQUIREMENTS OF THIS STANDARD ARE SHOWN IN THE FOLLOWING EXAMPLES. REFERENCE TO MATERIAL OR EQUIPMENT BY BRAND NAME, CATALOG NUMBER OR NAME OF MANUFACTURER IS INTENDED TO BE DESCRIPTIVE, NOT RESTRICTIVE, AND IS SOLELY FOR THE PURPOSE OF INDICATING TYPE OR QUALITY OF ITEM THAT IS ACCEPTABLE.

FIGURE 1

2 POLE FUSIBLE SAFETY SWITCH WITH SOLID NEUTRAL SQUARE "D" CO. TYPE A-87312 OR EQUAL.

FIGURE 2

3 POLE FUSIBLE SAFETY SWITCH, SQUARE "D" CO. TYPE A-86343 OR EQUAL.

FIGURE 3

3 POLE FUSIBLE SAFETY SWITCH WITH AUXILIARY CONTACTS, SQUARE "D" CO. TYPE H300 SERIES OR EQUAL.

FIGURE 4

6 POLE FUSIBLE SAFETY SWITCH WITH AUXILIARY CONTACTS, SQUARE "D" CO. TYPE H80000 SERIES OR EQUAL.

BLOCK DIAGRAMS OF TYPICAL SYSTEMS

FIGURE 5

FIGURE 8

FIGURE 6

FIGURE 7

FIGURE 9

② MILLIAMP AND KILOVOLT METERS

ES-1.9-15

GENERAL

MILLIAMP AND KILOVOLT METERS ARE CONTROL-PANEL MOUNTED ELECTRICAL METERS USED TO INDICATE OUTPUT CURRENT AND VOLTAGE OF AN X-RAY GENERATING SYSTEM.

THE METERS MAY BE CONNECTED IN THE HIGH-VOLTAGE CIRCUIT TO INDICATE X-RAY GENERATOR CURRENT AND VOLTAGE DIRECTLY, OR THEY MAY BE CONNECTED IN THE PRIMARY SIDE OF THE X-RAY TRANSFORMER AND CALIBRATED IN SECONDARY KILOVOLTS AND MILLIAMPS ACCORDINGLY.

MILLIAMP AND KILOVOLT METERS ARE NORMALLY SPECIFIED TO BE PART OF VENDOR-SUPPLIED EQUIPMENT.

DESCRIPTION

THE MILLIAMP AND KILOVOLT METERS MAY HAVE ROUND OR RECTANGULAR TYPE SCALES, LARGE ENOUGH TO BE EASILY READ. THEY SHOULD BE INSTALLED IN A POSITION FOR CONVENIENT VIEWING BY AN OPERATOR AT THE X-RAY CONTROL STATION. THE KILOVOLT METER SHOULD BE INSTALLED NEAR THE KILOVOLT-CONTROL SWITCH AND THE MILLIAMP METER SHOULD BE INSTALLED NEAR THE MILLIAMP-CONTROL SWITCH. EXAMPLES OF METER CONFIGURATIONS AND LOCATIONS THAT COMPLY WITH THESE REQUIREMENTS ARE SHOWN IN FIGURES 1 AND 2.

FIG. 1
SAMPLE CONTROL PANEL

FIG. 2
SAMPLE CONTROL PANEL

ELEMENTARY DIAGRAMS OF TYPICAL CIRCUITS

FIG. 3

FIG. 4

NOTE 1 - WHEN THE KILOVOLT METER IS CONNECTED IN THE PRIMARY OF THE HIGH-VOLTAGE SUPPLY, AS SHOWN IN FIGURE 3, IT MAY BE CONNECTED IN THE CIRCUIT BEFORE, OR AFTER, THE X-RAY CONTACTORS DEPENDING ON PREFERENCE OF THE X-RAY OPERATING GROUP.

NOTE 2 - WHEN METERS ARE CONNECTED IN THE SECONDARY OF THE HIGH-VOLTAGE SUPPLY, AS SHOWN IN FIGURES 3 AND 4, VOLTAGE ON METER CIRCUITS EXTERNAL TO THE POWER SUPPLY MUST BE LIMITED TO 300 VOLTS OR LESS BY MEANS OF SPARK GAPS, COLD CATHODE GAS-FILLED TUBES, OR OTHER SUITABLE VOLTAGE-LIMITING DEVICES CONNECTED FROM THE METER TERMINAL AT THE HIGH-VOLTAGE TANK TO EQUIPMENT GROUND.

③ SYSTEM ENERGIZING CONTACTOR(S)

ES-1.9-16

GENERAL

SYSTEM ENERGIZING CONTACTORS ARE ELECTRICAL CONTACTORS USED TO BREAK ALL SOURCE DRIVE OR HIGH VOLTAGE PRIMARY CONDUCTORS. ACTUATION OF THE CONTACTORS SHALL BE THE LAST STEP IN ENERGIZING A SYSTEM FOR X-RAY GENERATION OR SOURCE EXPOSURE.

IF AN EXISTING SYSTEM DOES NOT HAVE ALL SYSTEM ENERGIZING CONDUCTORS BROKEN, AN ADDITIONAL CONTACTOR MUST BE ADDED WHICH WILL BREAK ALL SYSTEM ENERGIZING CONDUCTORS, INCLUDING THE ONES ALREADY BROKEN. THE ADDITIONAL CONTACTOR SHALL BE ENERGIZED BEFORE THE EXISTING SYSTEM ENERGIZING CONTACTOR SO THAT REDUCED VOLTAGE SYSTEM ENERGIZING FEATURES OF THE SYSTEM ARE RETAINED. REDUNDANT CONTACTORS SHALL BE PROVIDED ON ALL SYSTEMS EQUAL TO OR ABOVE 100R/MIN./METER DOSAGE RATING. ACTUATION OF THE SYSTEM ENERGIZING CONTACTOR(S) SHALL ACTIVATE VISUAL AND/OR AUDIBLE WARNING DEVICES AS REQUIRED FOR PERSONNEL SAFETY. SYSTEM ENERGIZING CONTACTORS ARE REQUIRED ON ALL SYSTEMS THAT ARE ELECTRICALLY ACTUATED.

DESCRIPTION

SYSTEM ENERGIZING CONTACTORS THAT COMPLY WITH THE REQUIREMENTS OF THIS STANDARD ARE SHOWN IN THE FOLLOWING EXAMPLES. REFERENCE TO MATERIAL OR EQUIPMENT BY BRAND NAME, CATALOG NUMBER, OR NAME OF MANUFACTURER IS INTENDED TO BE DESCRIPTIVE, NOT RESTRICTIVE, AND IS SOLELY FOR THE PURPOSE OF INDICATING THE QUALITY OF ITEM THAT IS ACCEPTABLE.

FIG. 1

MAGNETIC CONTACTOR, 2 POLE, 15 AMP, ALLEN-BRADLEY CO. TYPE 702 SERIES

FIG. 2

MAGNETIC CONTACTOR, 2 POLE, 25 AMPS, GENERAL ELECTRIC CO. TYPE CR105K002

FIG. 3

MAGNETIC CONTACTOR, 3 POLE, SIZE 1, GENERAL ELECTRIC CO. TYPE CR105C002

FIG. 4

MERCURY PLUNGER CONTACTOR, 3 POLE, EBERT CO. TYPE A-111 (FOR SILENT OPERATION)

FIG. 5

MAGNETIC REVERSING CONTACTOR, 30, SIZE 00, ALLEN-BRADLEY CO. TYPE 705-TAB SERIES.

ELEMENTARY DIAGRAMS OF TYPICAL CIRCUITS

FIG. 6

NOTE 1: REVERSING CONTACTOR BREAKS ALL HOT CONDUCTORS TO SOURCE SHIELD ELEVATING MOTOR.

NOTE 2: XR1 CONTACTOR ADDED TO BREAK BOTH SIDES OF HV TRANSFORMER PRI.

NOTE 3: CONTACTOR XR2 ADDED FOR HV TRANSFORMER DE-ENERGIZING REDUNDANCY.

FIG. 7

FIG. 8

4 VOLTAGE SENSING DEVICE

ES-1.9-17

GENERAL

A VOLTAGE-SENSING DEVICE IS AN ELECTRICAL AND/OR ELECTRONIC DEVICE TO DETECT 10 VOLTS OR MORE IMPRESSED ON THE PRIMARY OF THE HIGH-VOLTAGE TRANSFORMER IN AN X-RAY GENERATING SYSTEM.

THE DEVICE SHALL BE INSTALLED DIRECTLY ACROSS THE HIGH-VOLTAGE TRANSFORMER PRIMARY, EXCEPT IN SPECIAL CASES WHERE SUCH INSTALLATION INTERFERES WITH NORMAL OPERATION OF THE MACHINE; FOR EXAMPLE, LOW POWER MACHINES SUCH AS SOME DXT GAGES EMPLOYING HIGH FREQUENCIES IN X-RAY GENERATION. ACTUATION OF THE VOLTAGE-SENSING DEVICE SHALL ACTIVATE VISUAL AND/OR AUDIBLE WARNING DEVICES AS REQUIRED FOR PERSONNEL SAFETY. DEENERGIZATION OF THE SYSTEM ENERGIZING CONTACTOR SHALL ELECTRICALLY ISOLATE THE VOLTAGE-SENSING DEVICE FROM THE NORMAL SYSTEM SUPPLY VOLTAGE.

DESCRIPTION

CIRCUITS AND COMPONENTS FOR A VOLTAGE-SENSING DEVICE THAT COMPLIES WITH REQUIREMENTS FOR THIS STANDARD ARE SHOWN IN THE FOLLOWING FIGURES. THIS DEVICE WILL OPERATE OVER A RANGE OF 10 TO 500 VOLTS ON A HIGH VOLTAGE TRANSFORMER PRIMARY. REFERENCE TO MATERIAL OR EQUIPMENT BY BRAND NAME, CATALOG NUMBER OR NAME OF MANUFACTURER IS INTENDED TO BE DESCRIPTIVE, NOT RESTRICTIVE, AND IS SOLELY FOR THE PURPOSE OF INDICATING TYPE OR QUALITY OF ITEM THAT IS ACCEPTABLE.

FIG. 1 PLAN VIEW

FIG. 2 SIDE VIEW

---INDICATES WIRING

COMPONENT IDENTIFICATION

D1, D2, D3, D4--500 MA, 500 VOLT, SILICON DIODES, TYPE 1N2071.

HS--HEAT SINK, 1" X 3" X 1/8" ALUMINUM.

VS--RELAY SENSITIVE, 5.17 VOLT DC, 2.65 MA, 1950A, WARD LEONARD CO. TYPE 250-38.

R1, R2, R3, R4--500Ω, 25 WATT WIREWOUND RESISTORS, MALLORY CO. TYPE 2.5 IJJ.

S--STANDOFF INSULATOR, 1" X 3/4", TAPPED FOR 6-32 SCREW.

TS--TERMINAL STRIP, CAMBRIDGE THERMONIC CORP. NO. ES1106.

Z--5.6 VOLT, 10 WATT ZENER DIODE, GENERAL INSTRUMENT CORPORATION TYPE 1N1601

FIG. 3 ELECTRICAL SCHEMATIC

ELEMENTARY DIAGRAMS OF TYPICAL SYSTEMS

FIG. 4

NOTE 1--CONNECT FLASHING LIGHT MODULE TO LOAD SIDE OF MAIN DISCONNECT SWITCH.

NOTE 2--CONNECT FLASHING LIGHT MODULE TO LOAD SIDE OF CONTROL SWITCH.

FIG. 5

5 RADIATION MONITOR

ES-1.9-18

GENERAL

A RADIATION MONITOR IS AN ELECTRONIC DEVICE USED TO DETECT PRESENCE OF X-RAY AND/OR NUCLEAR RADIATION.

THE RADIATION MONITOR SHALL BE A PERMANENTLY MOUNTED INTEGRAL PART OF THE SYSTEM PROTECTION SETUP AND SHALL ACTIVATE VISUAL AND/OR AUDIBLE WARNING DEVICES AS REQUIRED FOR PERSONNEL SAFETY. RADIATION MONITOR(S) SHALL BE PROVIDED WHERE AN X-RAY MACHINE DOSAGE RATING IS 25R/MIN/METER OR ABOVE.

DESCRIPTION

RADIATION MONITORS THAT COMPLY WITH THIS STANDARD ARE SHOWN IN THE FOLLOWING EXAMPLES. REFERENCE TO MATERIAL OR EQUIPMENT BY BRAND NAME OR MANUFACTURER IS INTENDED TO BE DESCRIPTIVE, NOT RESTRICTIVE, AND IS SOLELY FOR THE PURPOSE OF INDICATING TYPE OR QUALITY OF ITEM THAT IS ACCEPTABLE.

FIG. 1

AREA RADIATION MONITOR, NUCLEAR MEASUREMENTS CORP.
TYPE GA-2T.

FIG. 2

AREA RADIATION MONITOR, REMOTE INDICATING, VICTOREEN CORPORATION SERIES 700 MODEL; ALSO, GENERAL ELECTRIC CORPORATION SERIES NF10 ARM MODEL AND NUCLEAR MEASUREMENTS CORPORATION TYPE GA-2 WITH REMOTE PANEL.

ELEMENTARY DIAGRAMS OF TYPICAL CIRCUITS

FIG. 3

FIG. 4

NOTES:

1. ADD CIRCUIT IN DASHED LINES WHEN NUCLEAR SOURCE IS INSTALLED IN SAME FACILITY AS X-RAY.
2. MONITOR CONTACTS SHOWN IN NON-ACTIVATED STATE.

⑥ SOLENOID DOOR LOCK

ES-1.9-19

GENERAL

A SOLENOID DOOR LOCK IS AN ELECTRO-MECHANICAL, PLUNGER-TYPE DEVICE WHICH, WHEN DE-ENERGIZED, MECHANICALLY LOCKS THE ASSOCIATED SHIELD OR DOOR IN THE CLOSED POSITION.

THE DEVICE SHALL BE USED TO PREVENT ACCESS THROUGH DOORS AND/OR SHIELDS TO AN AREA WHEN HARMFUL RADIATION EXISTS IN THE AREA. FOR EXAMPLE, (1) USE OF SOLENOID-DOOR LOCKS INTERLOCKED TO PREVENT ENTRANCE TO A RADIOACTIVE SOURCE VAULT WHILE THE SOURCE IS EXPOSED; (2) SOLENOID-DOOR LOCKS USED IN CONJUNCTION WITH A RADIATION MONITOR TO PREVENT ACCESS TO AN AREA WHEN RADIATION EXISTS BECAUSE OF EQUIPMENT MALFUNCTION; (3) IN SPECIAL CASES (REFERENCE ES-1.9-20) THE SOLENOID-DOOR LOCK MAY BE TIMED TO PREVENT ACCESS TO A RADIATION AREA FOR A SPECIFIED TIME AFTER THE SYSTEM IS DE-ENERGIZED. IF AN ACCESS DOOR CAN BE OPENED ONLY BY AN ELECTRICAL OR HYDRAULIC MECHANISM, AN ELECTRICAL INTERLOCK, CONNECTED TO PREVENT OPERATION OF THE DOOR OPENER (AS IN FIGURE 4), SATISFIES REQUIREMENTS OF THIS STANDARD.

DESCRIPTION

SOLENOID-DOOR LOCKS THAT COMPLY WITH THIS STANDARD ARE DESCRIBED IN THE FOLLOWING EXAMPLES. REFERENCE TO MATERIAL OR EQUIPMENT BY BRAND NAME OR MANUFACTURER IS INTENDED TO BE DESCRIPTIVE, NOT RESTRICTIVE, AND IS SOLELY FOR THE PURPOSE OF INDICATING TYPE OR QUALITY OF ITEM THAT IS ACCEPTABLE.

FIG. 1

FIG. 2

ELECTRO-MECHANICAL LOCK
FOR SWINGING DOOR. FOLGER
ADAM COMPANY NO. 51 SERIES.

ELECTRO-MECHANICAL LOCK
FOR SLIDING DOOR. FOLGER
ADAM COMPANY NO. 55 SERIES

NOT SHOWN: ANDERSON
PRODUCTS COMPANY CATALOG
NO. B98721-1.
**FARADAY INC. CATALOG
NO. 8102**

ELEMENTARY DIAGRAMS OF TYPICAL CIRCUITS

FIG. 3

FIG. 4

7 VOLTAGE TIME DECAY CONTROL

ES-1.9-20

GENERAL

VOLTAGE TIME DECAY CONTROL IS A PROVISION TO PREVENT RADIATION EXPOSURE RESULTING FROM RESIDUAL VOLTAGE IN CONSTANT POTENTIAL POWER SUPPLIES.

IF THE EQUIPMENT DESIGN IS SUCH THAT SIGNIFICANT (AS DETERMINED BY RADIATION SAFETY) LEVELS OF RADIATION CAN EXIST AFTER THE EQUIPMENT IS TURNED OFF AND THE RADIATION AREA IS ACCESSIBLE TO PERSONNEL, ADDITIONAL SAFETY PROVISIONS WILL BE REQUIRED. EXAMPLES OF SUCH PROVISIONS ARE A POWER SUPPLY CAPACITOR PERMANENT BLEEDER RESISTOR, A POWER SUPPLY CAPACITOR SOLENOID OPERATED BLEEDER CIRCUIT, AND A CONTROLLED TIME DELAY ON A RADIATION AREA ACCESS DOOR OPENER.

ELEMENTARY DIAGRAMS OF TYPICAL CIRCUITS

CIRCUITS THAT COMPLY WITH REQUIREMENTS FOR THIS STANDARD ARE SHOWN IN THE FOLLOWING FIGURES:

FIGURE 1

FIGURE 2

ELEMENTARY DIAGRAMS OF TYPICAL CIRCUITS (CONTINUED)

FIG. 3

FIG. 4

8 ACCESS DOOR INTERLOCK

ES-1.9-22

GENERAL

AN ACCESS DOOR INTERLOCK SWITCH IS A DOOR OPERATED LIMIT SWITCH CONNECTED IN THE SYSTEM CONTROL CIRCUIT SUCH THAT THE RADIATION SOURCE CANNOT BE ENERGIZED OR EXPOSED WHILE THE DOOR TO THE RADIATION AREA IS OPEN.

THE ACCESS DOOR INTERLOCK SWITCH WILL BE USED ON ANY PERSONNEL ACCESS DOOR(S) IN VAULTS, CABINETS, OR OTHER ENCLOSURES WHERE THE PURPOSE OF THE DOOR IS TO PROVIDE NORMAL ACCESS TO THE RADIATION AREA WHILE THE X-RAY GENERATOR IS DE-ENERGIZED OR THE RADIATION SOURCE IS COMPLETELY SHIELDED. THIS INTERLOCK IS REQUIRED ON ALL ELECTRICALLY-OPERATED SYSTEMS

DESCRIPTION

AN ACCESS DOOR INTERLOCK SWITCH THAT COMPLIES WITH THE REQUIREMENTS OF THIS STANDARD IS SHOWN IN THE FOLLOWING EXAMPLE. REFERENCE TO MATERIAL OR EQUIPMENT BY BRAND NAME, CATALOG NUMBER, OR NAME OF MANUFACTURER IS INTENDED TO BE DESCRIPTIVE, NOT RESTRICTIVE, AND IS SOLELY FOR INDICATING THE QUALITY OF ITEM THAT IS ACCEPTABLE.

FIG. 1

LIMIT SWITCH, HEAVY DUTY OILTIGHT, ROLLER LEVER, DOUBLE POLE, DOUBLE THROW, 10 AMPS. MICRO-SWITCH TYPE ML.

ELEMENTARY DIAGRAMS OF TYPICAL CIRCUITS

FIG. 2

POSITION OF DOOR SWITCHES IN FIGURE 2 WILL BE AS SHOWN EXCEPT WHEN VAULT DOOR IS COMPLETELY CLOSED.

FIG. 3

10 ENCLOSURE PANELS INTERLOCK

ES-1.9-23

GENERAL

AN ENCLOSURE PANEL INTERLOCK SWITCH IS AN ENCLOSURE PANEL OPERATED ENCLOSED SWITCH CONNECTED IN THE SYSTEM CONTROL CIRCUIT SUCH THAT THE RADIATION SOURCE CANNOT BE ENERGIZED OR EXPOSED WHILE THE ENCLOSURE PANEL IS REMOVED.

THE ENCLOSURE PANEL INTERLOCK SWITCH WILL BE USED ON ANY ENCLOSURE PANEL WHERE THE PURPOSE OF THE PANEL IS TO LIMIT ACCESS TO THE RADIATION AREA WHILE THE X-RAY GENERATOR IS ENERGIZED OR THE RADIATION SOURCE IS EXPOSED. ENCLOSURE PANELS, BY DEFINITION, WILL BE LIMITED TO THOSE PANELS DESCRIBED ABOVE THAT ARE REMOVABLE WITHOUT TOOLS.

DESCRIPTION

AN ENCLOSURE PANEL INTERLOCK SWITCH THAT COMPLIES WITH THE REQUIREMENTS OF THIS STANDARD IS SHOWN IN THE FOLLOWING EXAMPLE. REFERENCE TO MATERIAL OR EQUIPMENT BY BRAND NAME, CATALOG NUMBER, OR NAME OF MANUFACTURER IS INTENDED TO BE DESCRIPTIVE, NOT RESTRICTIVE, AND IS SOLELY FOR THE PURPOSE OF INDICATING THE QUALITY OF ITEM THAT IS ACCEPTABLE.

FIG. 1

ENCLOSED SWITCH, SINGLE POLE, DOUBLE THROW, MOMENTARY CONTACT, 15 AMP, 120 VOLTS, 60 HZ, MICRO SWITCH, TYPE E6.

NOTES

1. ADD CKT. IN DASHED LINES WHEN NUCLEAR SOURCE IS USED IN SAME FACILITY AS X-RAY.

ELEMENTARY DIAGRAMS OF TYPICAL CIRCUITS

FIG. 2

FIG. 3

11 RADIATION SHIELD INTERLOCK

ES-1.9-24

GENERAL

A RADIATION SHIELD INTERLOCK SWITCH IS A RADIATION SHIELD OPERATED ENCLOSED SWITCH CONNECTED IN THE SYSTEM CONTROL CIRCUIT SUCH THAT THE RADIATION SOURCE CANNOT BE ENERGIZED OR EXPOSED WHILE THE RADIATION SHIELD IS REMOVED.

THE RADIATION SHIELD INTERLOCK SWITCH WILL BE USED ON ANY SHIELD WHERE THE PURPOSE OF THE SHIELD IS TO PREVENT RADIATION FROM PENETRATING A WORK AREA WHILE THE X-RAY GENERATOR IS ENERGIZED OR THE RADIATION SOURCE IS EXPOSED. RADIATION SHIELDS, BY DEFINITION, WILL BE LIMITED TO THOSE SHIELDS DESCRIBED ABOVE THAT ARE REMOVABLE WITHOUT TOOLS.

DESCRIPTION

A RADIATION SHIELD INTERLOCK SWITCH THAT COMPLIES WITH THE REQUIREMENTS OF THIS STANDARD IS SHOWN IN THE FOLLOWING EXAMPLE. REFERENCE TO MATERIAL OR EQUIPMENT BY BRAND NAME, CATALOG NUMBER, OR NAME OF MANUFACTURER IS INTENDED TO BE DESCRIPTIVE, NOT RESTRICTIVE, AND IS SOLELY FOR THE PURPOSE OF INDICATING THE QUALITY OF ITEM THAT IS ACCEPTABLE.

FIG. 1

ENCLOSED SWITCH, SINGLE POLE,
DOUBLE THROW, MOMENTARY CONTACT,
15 AMP, 120 VOLTS, 60 HZ, MICRO
SWITCH, TYPE E6.

ELEMENTARY DIAGRAMS OF TYPICAL CIRCUITS

FIG. 2

NOTES:

1. ADD CIRCUIT IN DASHED LINES WHEN NUCLEAR SOURCE IS INSTALLED IN SAME FACILITY AS X-RAY.

FIG. 3

12 BARRICADE INTERLOCK

ES-1.9-25

GENERAL

A BARRICADE INTERLOCK SWITCH IS A BARRICADE OPERATED ENCLOSED SWITCH CONNECTED IN THE SYSTEM CONTROL CIRCUIT SUCH THAT THE RADIATION SOURCE CANNOT BE ENERGIZED OR EXPOSED WHILE THE BARRICADE IS REMOVED.

THE BARRICADE INTERLOCK SWITCH WILL BE USED ON ANY BARRICADE WHERE THE PURPOSE OF THE BARRICADE IS TO LIMIT ACCESS TO THE RADIATION AREA WHILE THE X-RAY GENERATOR IS ENERGIZED OR THE RADIATION SOURCE IS EXPOSED.

DESCRIPTION

A BARRICADE INTERLOCK SWITCH THAT COMPLIES WITH THE REQUIREMENTS OF THIS STANDARD IS SHOWN IN THE FOLLOWING EXAMPLE. REFERENCE TO MATERIAL OR EQUIPMENT BY BRAND NAME, CATALOG NUMBER, OR NAME OF MANUFACTURER IS INTENDED TO BE DESCRIPTIVE, NOT RESTRICTIVE, AND IS SOLELY FOR THE PURPOSE OF INDICATING THE QUALITY OF ITEM THAT IS ACCEPTABLE.

ENCLOSED SWITCH, SINGLE POLE,
DOUBLE THROW, MOMENTARY CONTACT,
15 AMP, 120 VOLTS, 60 HZ, MICRO
SWITCH, TYPE E6.

NOTES

1. ADD CKT. IN DASHED LINES WHEN NUCLEAR SOURCE IS USED IN SAME FACILITY AS X RAY.

FIG. 1**ELEMENTARY DIAGRAMS OF TYPICAL CIRCUITS** **FIG. 2** **FIG. 3**

13 SCRAM SWITCH INTERLOCK

ES-1.9-26

GENERAL

A SCRAM SWITCH IS A MANUALLY OPERATED PUSHBUTTON SWITCH CONNECTED IN THE SYSTEM-CONTROL CIRCUIT TO (1) DE-ENERGIZE OR SHIELD A RADIATION SOURCE UNDER EMERGENCY CONDITIONS UNTIL THE SWITCH HAS BEEN RESET AFTER IT HAS BEEN ACTUATED, AND (2) UNLOCK AND/OR OPEN VAULT DOORS FOR EMERGENCY EGRESS.

THE MANUALLY-OPERATED SWITCH IS REQUIRED IN VAULTS AND BARRICADED AREAS TO PROVIDE EMERGENCY SHUTDOWN OF THE SYSTEM BY PERSONNEL IN THE AREA. THE SCRAM SWITCH(ES) WILL BE LOCATED IN A CONVENIENTLY ACCESSIBLE PLACE IN THE WORK AREA AND WILL BE PROMINENTLY IDENTIFIED AS AN EMERGENCY SHUTDOWN MEANS. THE SWITCH SHALL HAVE A MAINTAINED "OFF" POSITION THAT CAN ONLY BE RESET TO THE "ON" POSITION AT ITS IMMEDIATE LOCATION.

DESCRIPTION

AN EMERGENCY SCRAM PUSHBUTTON SWITCH THAT COMPLIES WITH THE REQUIREMENTS OF THIS STANDARD IS SHOWN IN THE FOLLOWING EXAMPLE. REFERENCE TO MATERIAL OR EQUIPMENT BY BRAND NAME, CATALOG NUMBER, OR NAME OF MANUFACTURER IS INTENDED TO BE DESCRIPTIVE, NOT RESTRICTIVE, AND IS SOLELY FOR INDICATING THE QUALITY OF ITEM THAT IS ACCEPTABLE.

FIG. 1

PUSHBUTTON UNIT, HEAVY DUTY OILTIGHT, WITH MOMENTARY CONTACT BLOCK, DOUBLE POLE, DOUBLE THROW, 2 N.O. AND 2 N.C., 10 AMP. RATED CONTACTS AND A MAINTAIN TYPE SINGLE 2 1/4 INCH RED MUSHROOM HEAD BUTTON OPERATOR WHICH WILL "PUSH TO STOP" AND "PULL TO RESET" FURNAS ELECTRIC CO, CLASS 50

ELEMENTARY DIAGRAMS OF TYPICAL CIRCUITS

FIG. 2

FIG. 3

14 FORCED INSPECTION INTERLOCK

ES-1.9-27

GENERAL

A "FORCED INSPECTION" INTERLOCK IS A MANUALLY OPERATED PUSHBUTTON OR KEY SWITCH CONNECTED IN THE SYSTEM CONTROL CIRCUIT SUCH THAT THE RADIATION SOURCE MAY BE ENERGIZED ONLY DURING A PRESET TIME INTERVAL.

THE MANUALLY OPERATED SWITCH WILL BE INSTALLED IN VAULTS AND BARRICADED AREAS IN A WAY THAT WILL FORCE SURVEILLANCE OF THE AREA FOR PERSONNEL WHO MAY HAVE ENTERED UNNOTICED.

DESCRIPTION

A "FORCED INSPECTION" SWITCH THAT COMPLIES WITH THE REQUIREMENTS OF THIS STANDARD IS SHOWN IN THE FOLLOWING EXAMPLES. REFERENCE TO MATERIAL OR EQUIPMENT BY BRAND NAME, CATALOG NUMBER, OR NAME OF MANUFACTURER IS INTENDED TO BE DESCRIPTIVE, NOT RESTRICTIVE, AND IS SOLELY FOR THE PURPOSE OF INDICATING THE QUALITY OF ITEM THAT IS ACCEPTABLE.

FIG. 1

PUSHBUTTON UNIT, HEAVY DUTY OILTIGHT, WITH MOMENTARY CONTACT BLOCK, SINGLE POLE, DOUBLE THROW, 1 N.O. AND 1 N.C., 6 AMP RATED CONTACTS, WITH EITHER A FLUSH-HEAD OPERATOR AND BLACK BUTTON OR A CYLINDER KEY-LOCK OPERATOR. ALLEN-BRADLEY, BULLETIN 800T.

FIG. 2

ELEMENTARY DIAGRAMS OF TYPICAL CIRCUITS

FIG. 3

FIG. 4

NOTES:

1. ADD CIRCUIT IN DASHED LINES WHEN NUCLEAR SOURCE IS INSTALLED IN SAME FACILITY AS X-RAY.

15 RADIATION BEAM POSITION INTERLOCK

ES-1.9-28

GENERAL

A RADIATION BEAM POSITION INTERLOCK SWITCH(ES) IS A RADIATION BEAM POSITION OPERATED ENCLOSED SWITCH(ES) CONNECTED IN THE SYSTEM CONTROL CIRCUIT SUCH THAT THE RADIATION SOURCE WILL BE DE-ENERGIZED IF IT IS NOT AIMED WITHIN THE PRESCRIBED DIRECTIONS SHIELDING IS SOMETIMES DESIGNED FOR CERTAIN OPERATING DIRECTIONS AND IS NOT ADEQUATE FOR OTHERS. IN SUCH CASES THE EQUIPMENT IS INTERLOCKED TO PREVENT SUCH OPERATION. FOR EXAMPLE, THE SHIELD OVER AN X-RAY MACHINE MAY NOT BE DESIGNED TO ADEQUATELY SHIELD THE DIRECT BEAM ON THE PREMISE THAT IT WOULD NEVER BE NECESSARY TO AIM THE DIRECT BEAM TOWARD THE CEILING. IN SUCH A CASE THE MACHINE WOULD BE INTERLOCKED TO PREVENT AIMING IT IN THAT DIRECTION.

DESCRIPTION

A RADIATION BEAM POSITION INTERLOCK SWITCH(ES) THAT COMPLIES WITH THE REQUIREMENTS OF THIS STANDARD IS SHOWN IN THE FOLLOWING EXAMPLE. REFERENCE TO MATERIAL OR EQUIPMENT BY BRAND NAME, CATALOG NUMBER, OR NAME OF MANUFACTURER IS INTENDED TO BE DESCRIPTIVE, NOT RESTRICTIVE, AND IS SOLELY FOR THE PURPOSE OF INDICATING THE QUALITY OF ITEM THAT IS ACCEPTABLE.

ENCLOSED SWITCH, SINGLE POLE, DOUBLE THROW, MOMENTARY CONTACT, 15 AMP, 120 VOLTS, 60 HZ, MICRO SWITCH, TYPE E6.

FIG. 1

ELEMENTARY DIAGRAMS OF TYPICAL CIRCUITS

FIG. 2

FIG. 3

NOTES:

1. ADD CIRCUIT IN DASHED LINES WHEN NUCLEAR SOURCE IS INSTALLED IN SAME FACILITY AS X-RAY.

16 LIGHT FAILURE INTERLOCK

ES-1.9-29

GENERAL

A LIGHT FAILURE INTERLOCK IS AN ELECTRICAL AND/OR ELECTRONIC DEVICE TO DETECT THE FAILURE OF ONE OR MORE OF THE WARNING LIGHTS AND DE-ENERGIZE THE RADIATION SOURCE.

THE LIGHT FAILURE INTERLOCK DEVICE SHALL BE CONNECTED IN THE SYSTEM CONTROL CIRCUIT SUCH THAT IF ONE OR MORE OF THE FLASHING WARNING LIGHTS FAIL THE DEVICE WILL DE-ENERGIZE THE X-RAY RADIATION SOURCE OR SHIELD THE RADIOACTIVE SOURCE. THIS DEVICE WOULD BE USED WHERE THERE IS A HIGH-LEVEL HAZARD OR WHERE THE SAFETY OF PERSONNEL IS HEAVILY DEPENDING UPON SAFETY LIGHTS.

DESCRIPTION

A LIGHT FAILURE INTERLOCK DEVICE THAT COMPLIES WITH THE REQUIREMENTS OF THIS STANDARD IS SHOWN IN THE FOLLOWING EXAMPLE. REFERENCE TO MATERIAL OR EQUIPMENT BY BRAND NAME, CATALOG NUMBER, OR NAME OF MANUFACTURER IS INTENDED TO BE DESCRIPTIVE, NOT RESTRICTIVE, AND IS SOLELY FOR THE PURPOSE OF INDICATING THE QUALITY OF ITEM THAT IS ACCEPTABLE.

LIGHT FAILURE ELEMENTARY DIAGRAM

(FOR INSTALLATION WITH MORE THAN TWO SETS OF 120 VOLT,
100 WATT FLASHING LAMPS.)

- (a) USE XRX & VSX FOR X-RAY SYSTEMS,
(b) USE DNX & MX FOR SOURCE SYSTEMS,
③ TERMINAL POINTS FOR EXTERNAL CONNECTIONS.

- SC1-SC2 - TRIAC, BI-DIRECTIONAL, SILICON, GATE CONTROLLED, GENERAL ELECTRIC TYPE SC45B,
LT1-LT2 - 125 VOLT INCANDESCENT LAMPS WITH RED OR MAGENTA GLOBE & GUARD, SEE ES-1.9-37 & 38,
CT - LIGHT FAILURE PROTECTIVE SENSOR TRANSFORMER, J-10 AMPS, 60 HZ, GUARDIAN TYPE IR-CT1-202,
LF - LIGHT FAILURE PROTECTIVE SENSOR RELAY, 120 VOLTS, 0.10-.40 SEC. TIME DELAY ON RELEASE, GUARDIAN P/N2121-0996-2206,
LFX - LIGHT FAILURE AUX. RELAY, 120 VOLT COIL, ALLEN-BRADLEY TYPE N, WITH TIMER STACK, TIME RANGE 0.1 TO 5 SEC.,
LFLT - LIGHT FAILURE, PILOT LT. TRANSF. TYPE, 120 VOLTS, 60 HZ, WITH AMBER LENS, SQUARE D CLASS 9001,
R-14 - TIMING RESISTOR, COMP. CARBON, FIXED, 1/2W, NOMINAL RESISTANCE 10,000 OHMS (50,000 OHMS/SEC.),
LFPB - LIGHT FAILURE PUSHBUTTON, ONE N.O. CONTACT, TO RESET LFX RELAY.

NOTES:

- ALL RELAY CONTACTS ARE SHOWN WITH RELAY IN DE-ENERGIZED CONDITION.
- WITH X-RAY OFF AND RADIOACTIVE SOURCE SHIELDED AND CONTROL POWER ON THE FOLLOWING CONDITIONS EXIST:
 - THE SYSTEM ENERGIZING CONTACTOR AUX. RELAY XRX, THE VOLTAGE SENSING DEVICE AUX. RELAY VSX, AND THE SHIELD CLOSED AUX. RELAY DNX ARE DE-ENERGIZED.
 - THE RADIATION MONITOR AUX. RELAY MX IS ENERGIZED.
 - THE LIGHT FAILURE RELAY LF AND THE LIGHT FAILURE AUX. RELAY LFX ARE DE-ENERGIZED. THE LFX RELAY HAS ONE OR MORE INSTANTANEOUS CONTACTS AND TWO TIME DELAY CONTACTS (DELAY ON PICK-UP).
 - THE LIGHT FAILURE LAMP LFLT IS ENERGIZED.
 - THE LIGHT FAILURE TIME DELAY RELAY TDR/LF (DELAY ON DROP-OUT) IS ENERGIZED.

TO ENERGIZE THE X-RAY OR EXPOSE THE SOURCE THE FOLLOWING ACTIONS MUST BE TAKEN:

- RESET THE LIGHT FAILURE CIRCUIT BY ACTUATING THE RESET PUSHBUTTON. THIS WILL ENERGIZE RELAY LFX THROUGH THE CLOSED CONTACT OF RELAY TDR/LF. A LFX TIME DELAY CONTACT WILL SEAL IN AROUND THE PUSHBUTTON. THE OTHER LFX TIME DELAY CONTACT WILL DE-ENERGIZE THE LIGHT FAILURE LAMP LFLT. THE LFX INSTANTANEOUS CONTACTS CLOSE IN ONE AND/OR THE OTHER UNITS INTERLOCK CIRCUIT.
- ACTUATE THE X-RAY ON OR EXPOSE SOURCE PUSHBUTTON. THE SYSTEM ENERGIZING CONTACTORS WILL BE ENERGIZED. IF THE FLASHING RED WARNING LIGHTS ARE GOOD THEN THE LIGHT FAILURE RELAY LF WILL BE ENERGIZED. THE LF CONTACT WILL THEN KEEP THE LFX RELAY ENERGIZED AFTER THE TIMED CONTACT OF RELAY TDR/LF HAS OPENED. THE UNIT WILL REMAIN ENERGIZED.
- IF THE FLASHING RED WARNING LIGHTS ARE NOT GOOD OR ONE OR MORE SHOULD BURN OUT DURING OPERATION, THE LIGHT FAILURE RELAY LF WILL DE-ENERGIZE AND DROP OUT THE LIGHT FAILURE AUX. RELAY LFX WHICH WILL DE-ENERGIZE THE X-RAY UNIT OR SHIELD THE RADIOACTIVE SOURCE AND ENERGIZE THE LIGHT FAILURE LAMP LFLT.

DESCRIPTION

A LIGHT FAILURE INTERLOCK DEVICE FOR USE WITH ANALYTICAL X-RAY EQUIPMENT THAT COMPLIES WITH THE REQUIREMENTS OF THIS STANDARD IS SHOWN IN THE FOLLOWING EXAMPLE. REFERENCE TO MATERIAL OR EQUIPMENT BY BRAND NAME, CATALOG NUMBER, OR NAME OF MANUFACTURER IS INTENDED TO BE DESCRIPTIVE, NOT RESTRICTIVE, AND IS SOLELY FOR THE PURPOSE OF INDICATING THE QUALITY OF ITEM THAT IS ACCEPTABLE.

COMPONENT IDENTIFICATION

- T1 - TRANSFORMER, 120 VOLT PRIMARY, THREE 12 VOLT SEC. WINDINGS, CHICAGO STANDARD TRANSF. TYPE P-8364.
- PCB 1 - LIGHT FLASHER PRINTED CIRCUIT BOARD AS SHOWN IN DIAGRAM 1, PAGE 3.
- PCB 2 - LIGHT FAILURE PRINTED CIRCUIT BOARD AS SHOWN IN DIAGRAM 2, PAGE 3.
- LT1 & LT2 - PILOT LIGHT ASSEMBLY FOR USE WITH A T-3-1/4 MBB LAMP #47, RED LENS.
- LFLT - LIGHT FAILURE PILOT LIGHT ASSEMBLY FOR USE WITH A T-3-1/4 MBB LAMP #47, AMBER LENS.
- LFX - LIGHT FAILURE AUX. RELAY, 120 VOLT COIL, ALLEN-BRADLEY TYPE N, WITH TIMER STACK, TIME RANGE 0.1 TO 5 SEC.
- R5 & R6 - RESISTOR, COMP. CARBON, FIXED, 1 WATT, 27 OHMS.
- H1 & H2 - SONALERT ELECTRONIC AUDIBLE SIGNAL, 2800 HZ, 6-28 VOLTS D.C., MALLORY SC628.
- SW1 & SW2 - SWITCH TOGGLE, SPDT, 125 VOLT, 6 A.
- R14 - TIMING RESISTOR, COMP. CARBON, FIXED, 1/2 W, NOMINAL RESISTANCE 10,000 OHMS (50,000 OHMS/SEC.)
- LFPB - LIGHT FAILURE PUSHBUTTON, ONE N.O. CONTACT, TO RESET LFX RELAY.

LIGHT FAILURE ELEMENTARY DIAGRAM

ELEMENTARY DIAGRAM OF TYPICAL CIRCUIT

PRINTED CIRCUIT BOARD 1
DIAGRAM 1

PRINTED CIRCUIT BOARD 2
DIAGRAM 2

COMPONENT IDENTIFICATION

- LF - PROTECTIVE SENSOR RELAY, 120 VOLTS, GUARDIAN TYPE IR-CS1-220.
 D1-D8 - DIODE, SILICON, IN4006.
 Q1-Q2 - TRANSISTOR, 2N2084.
 Q3-Q5 - TRANSISTOR, 2N526.
 C1-C2 - CAPACITOR, FIXED, DRY ELECTROLYTIC, 1000 MFD, 15 VDC, MALLORY.
 C3-C4 - CAPACITOR, FIXED, DRY ELECTROLYTIC, 50 MFD, 50 VDC, MALLORY.
 R1-R4 - RESISTOR, COMP. CARBON, FIXED, 1/2W, 2400 OHMS.
 R7-R8 - RESISTOR, COMP. CARBON, FIXED, 1/2W, 27,000 OHMS.
 R9 - RESISTOR, COMP. CARBON, FIXED, 1/2W, 180 OHMS.
 R10 - RESISTOR, COMP. CARBON, FIXED, 1/2W, 7.5 OHMS.
 R11-R12 - RESISTOR, COMP. CARBON, FIXED, 1/2W, 240 OHMS.
 R13 - RESISTOR, COMP. CARBON, FIXED, 1/2W, 10,000 OHMS.
 C5-C6 - CAPACITOR, FIXED, DRY ELECTROLYTIC, 150 MFD, 50 VDC, MALLORY.
 C7 - CAPACITOR, FIXED, DRY ELECTROLYTIC, 1 MFD, 25 VDC, MALLORY.
 D9-D12 - BRIDGE RECTIFIER, MALLORY TYPE MAL-7250.
 TDR/LF - TIME DELAY RELAY LIGHT FAILURE, DELAY ON DROP-OUT, 12 VOLT COIL, TIME RANGE 200 MSEC-100 SEC., 50,000 OHMS/SEC., MAGNECRAFT W503-PCSRX-2.
 VSX/LF - VOLTAGE SENSING AUX. RELAY, LIGHT FAILURE, DRY REED, 6 VDC COIL, MAGNECRAFT W103PCX-1.
 XR/LF - X-RAY ON AUX. RELAY, LIGHT FAILURE, DRY REED, 6 VDC COIL, MAGNECRAFT W103PCX-1.
 R15-R16 - RESISTOR, COMP. CARBON, FIXED, 1/2 W, 1000 OHMS.

REFERENCE DWG.

- C-E-36000- STANDARD FLASHING LIGHTS P.C. BOARD #1.
 C-E-36001- STANDARD FLASHING LIGHTS P.C. BOARD #1.
 C-E-35999 - STANDARD FLASHING LIGHTS P.C. BOARD #1.
 D-E-53219 - X-RAY FACILITIES STANDARD LIGHT FAILURE P.C.B. #2 LAYOUT
 D-E-53220 - X-RAY FACILITIES STANDARD LIGHT FAILURE P.C.B. #2 LAYOUT
 D-E-53221 - X-RAY FACILITIES STANDARD LIGHT FAILURE P.C.B. #2 SCHEMATIC DIAG.
 E-E-88358 - X-RAY FACILITIES STANDARD LIGHT FAILURE BOARD LAYOUT & WIRING DIAGRAM.

ELEMENTARY DIAGRAMS OF TYPICAL CIRCUITS CONT.

17 KEY LOCK-OUT INTERLOCK

ES-1.9-30

GENERAL

A KEY LOCK-OUT IS A KEY OPERATED CONTROL SWITCH THAT MUST BE ACTIVATED BEFORE THE SYSTEM CAN BE ENERGIZED.

KEY LOCK-OUTS ARE APPROPRIATE IN SITUATIONS WHERE THE RADIATION PART OF THE SYSTEM IS ISOLATED FROM THE CONTROL CONSOLE. IN SPECIAL CASES THIS SAFETY FEATURE CAN BE USED TO REPLACE OR SUPPLEMENT ACCESS DOOR INTERLOCK SWITCHES BY HAVING ONE KEY WHICH CAN ONLY BE REMOVED FROM AN ACCESS DOOR WHEN THE DOOR IS LOCKED. A KEY LOCK-OUT MAY ALSO BE USED AS AN INTEGRAL PART OF A FORCED INSPECTION SAFETY FEATURE.

DESCRIPTION

KEY LOCK-OUT SWITCHES SHOULD BE INSTALLED ON OR NEAR THE SYSTEM CONTROL CONSOLE. EXAMPLES OF SWITCHES AND MOUNTING LOCATIONS THAT COMPLY WITH THESE REQUIREMENTS ARE SHOWN IN FIGURES 1 AND 2. REFERENCE TO MATERIAL OR EQUIPMENT BY BRAND NAME, CATALOG NUMBER, OR NAME OF MANUFACTURER IS INTENDED TO BE DESCRIPTIVE, NOT RESTRICTIVE, AND IS SOLELY FOR THE PURPOSE OF INDICATING TYPE OR QUALITY OF ITEM THAT IS ACCEPTABLE.

FIG. 1

SHOWING KEY LOCK-OUT SWITCH MOUNTED ON CONTROL CONSOLE.

TWO POSITION SELECTOR SWITCH UNIT HEAVY DUTY OILTIGHT WITH MAINTAINED CONTACT BLOCK, 1 N.O. AND 1 N.C., 6 AMP RATED CONTACTS, CYLINDER KEY LOCK OPERATOR, KEY REMOVABLE IN LEFT POSITION ONLY, ALLEN-BRADLEY BULLETIN 800T.

FIG. 2

SHOWING KEY LOCK-OUT SWITCH SUITABLE FOR MOUNTING APART FROM CONTROL CONSOLE.

ELEMENTARY DIAGRAMS OF TYPICAL CIRCUITS

FIG. 3

POSITION OF DOOR SWITCHES IN FIGURE 3 WILL BE AS SHOWN EXCEPT WHEN VAULT DOOR IS COMPLETELY CLOSED.

FIG. 4

FIG. 5

ELEMENTARY DIAGRAMS OF TYPICAL CIRCUITS (CONT'D.)

FIG. 6

FIG. 7

18 FAIL STRIP INTERLOCK

ES-1.9-31

GENERAL

A FAIL STRIP INTERLOCK IS A RIBBON SWITCH, INSTALLED ON A WALL OR CEILING OR BARRICADE THAT DE-ENERGIZES THE SYSTEM IF IT IS BROKEN OR ACTIVATED BY PRESSURE.

SUCH A STRIP INTERLOCK SHALL BE INSTALLED WHERE THERE IS DANGER THAT THE INTEGRITY OF VAULT, ROOM, OR OTHER ENCLOSURE MIGHT BE BREACHED INADVERTENTLY. FOR EXAMPLE, SUCH AN INTERLOCK SHALL BE USED ON A THIN-WALLED ROOM ADJACENT TO A HEAVY MAINTENANCE OR CONSTRUCTION AREA, OR WHERE ADJACENT TO FORK LIFT TRAFFIC.

DESCRIPTION

A FAIL STRIP DEVICE THAT COMPLIES WITH THIS STANDARD IS DESCRIBED IN THE FOLLOWING EXAMPLE. REFERENCE TO MATERIAL OR EQUIPMENT BY BRAND NAME, CATALOG NUMBER, OR NAME OF MANUFACTURER IS INTENDED TO BE DESCRIPTIVE, NOT RESTRICTIVE, AND IS SOLELY FOR THE PURPOSE OF INDICATING TYPE OR QUALITY OF ITEM THAT IS ACCEPTABLE.

COMPONENT IDENTIFICATION

FSX - CONTROL RELAY, 120 VAC, DPDT, GUARDIAN TYPE 2200 U-DPDT-120

FS - RELAY, SENSITIVE, 5.17 VDC, 1950 OHM, WARD LEONARD TYPE 250-38.

C - CAPACITOR, 100 MFD, 50 V, MALLORY CO. TYPE TCM.

D1, D2, D3, D4 - DIODE 500 MA, 500 V TYPE IN2071.

R - RESISTOR, 1 K OHM, 1 W, CARBON, ALLEN-BRADLEY CO. TYPE EB.

RS - RIBBON SWITCH MATERIAL, PRESSURE ACTIVATED BY 12 OZ. OR 40 OZ. PRESSURE, TAPESWITCH CORPORATION OF AMERICA TYPE 102-B.

TI - TRANSFORMER, VOLTAGE, 5 VA, 120 VOLT PRIMARY, 10 VOLT SECONDARY, EDWARDS CO. TYPE 990.

TB1 - TERMINAL, STRIP, 8 PT, 6-32 SCREWS, CINCH-JONFS CO. TYPE 8-141.

TB2, TB3 - TERMINAL, MOULDED, FOR RIBBON SWITCH, TAPESWITCH CORPORATION OF AMERICA TYPE 103-B.

Z - ZENER DIODE, 5.6 V, 0.4 W, TYPE IN 752A.

FIG. 1: ELEMENTARY WIRING DIAGRAM

FIG. 2: SCHEMATIC DIAG.

ELEMENTARY DIAGRAMS OF TYPICAL CIRCUITS

FIG. 3

FIG. 4

(20) SIGNS

ES-1.9-33

General

Signs as described in this standard are prepared as visual warning devices to be used in and around radiation producing systems to warn personnel of radiation hazards. Specifying the number, kind, and location of warning signs will be the responsibility of the group in charge of the facility with assistance from the Radiation Safety Department.

All warning signs shall include (a) an approved heading that indicates the relative hazard, (b) a statement of the type of hazard, (c) a statement of action required in the area, (d) a prominently displayed three-bladed reddish purple propeller radiation symbol on a yellow background.

Warning signs for radiation hazards shall be divided into two classifications as follows:

Danger Signs

Danger signs shall be used where exposure of personnel could result in injurious doses of radiation. The heading of this sign states "Danger" in white letters on a red oval edged with a rectangular black border. The body is white and the message is black. The sign will also display a prominent three-bladed reddish purple propeller radiation symbol on a yellow background.

Caution Signs

Caution signs shall be used where exposure can result in exceeding radiation protection guide values but unlikely to cause clinically detectable injurious doses to personnel. The heading of this sign states "Caution" in yellow letters on a black rectangle. The body is yellow and the message is black. The sign will also display a prominent three-bladed reddish purple propeller radiation symbol.

Description

All warning signs shall be fabricated of 1/16-inch-thick aluminum. They shall be furnished with rounded or blunt corners and shall be free from sharp edges, burrs, or other projections. Fastening devices shall be installed in such a way that they do not constitute a hazard.

The "Danger" signs shall have a white background of a dry adhesive sheeting (3M Co. Scotchcal film #650 white). The background for the standard radiation symbol shall be a dry adhesive sheeting (3M Co. Scotchcal film #652 yellow). The colors red, black, and reddish purple shall be a gloss vinyl ink (Naz-Dar Co. red #GV-109, black #GV-111, and reddish purple #GV-13349). The standard proportions of the sign shall be as shown in Table 1.

The "Caution" signs shall have a yellow background of a dry adhesive sheeting (3M Co. Scotchcal film #652 yellow). The colors black and reddish purple shall be a gloss vinyl ink (Naz-Dar Co. black #GV-111, and reddish purple #GV-13349). The standard proportions of the sign shall be as shown in Table 2.

Examples of signs are shown in Figures 1 through 5.

When conditions warrant the use of a sign size not covered in these standards, the ratio of the depth of the identifying panel (Danger or Caution) to the width of the sign shall be as established in Tables 1 and 2. The size of lettering to be used for the wording of the sign or message should be as large as possible but consistent with good balance and legibility. Block-style lettering should be used.

The method of dimensioning, design, and orientation of the standard three-bladed radiation symbol (one blade pointed downward and centered on the vertical axis) shall be executed as shown in Figure 6.

Reference to material or equipment by brand name, catalog number, or name of manufacturer is intended to be descriptive, not restrictive, and is solely for the purpose of indicating type of quality of item that is acceptable.

Table 1

STANDARD PROPORTIONS FOR DANGER SIGNS

Sign Size Inches		Black Rectangular Panel, Inches		Red Oval Inches		Word Danger Height of Letter Inches	Maximum Space Available for Sign Wording Inches
Height	Width	Height	Width	Height	Width		
HORIZONTAL PATTERN							
7	x 10	3 1/4	x 9 3/8	2 7/8	x 8 1/2	1 7/16	2 3/4 x 9 3/8
10	x 14	4 5/8	x 13 3/8	4 1/8	x 11 7/8	2 1/16	4 1/4 x 13 3/8
14	x 20	6 1/2	x 19 3/8	5 3/4	x 17	2 7/8	6 1/4 x 19 3/8
20	x 28	9 1/4	x 27 3/8	8 1/4	x 23 7/8	4 1/8	9 1/2 x 27 3/8
UPRIGHT PATTERN							
10	x 7	2 3/8	x 6 3/8	2 1/8	x 5 7/8	1 1/16	6 3/8 x 6 3/8
14	x 10	3 1/4	x 9 3/8	2 7/8	x 8 1/2	1 7/16	9 1/2 x 9 3/8
20	x 14	4 5/8	x 13 3/8	4 1/8	x 11 7/8	2 1/16	14 x 13 3/8
28	x 20	6 1/2	x 19 3/8	5 3/4	x 17	2 7/8	20 1/4 x 19 3/8

Examples of signs are shown in Figs. 1-5.

Table 2
STANDARD PROPORTIONS FOR CAUTION SIGNS

Sign Size Inches			Black Rectangular Panel, Inches			Word Caution Height of Letter Inches	Maximum Space Available for Sign Wording Inches
Height		Width	Height		Width		
HORIZONTAL PATTERN							
7	x	10	2 1/4	x	9 3/8	1 5/8	3 1/4 x 9 3/8
10	x	14	3 1/4	x	13 3/8	2 1/4	5 1/2 x 13 3/8
14	x	20	3 3/4	x	19 3/8	2 3/4	9 x 19 3/8
20	x	28	4 1/4	x	27 3/8	3 1/4	14 1/2 x 27 3/8
UPRIGHT PATTERN							
10	x	7	1 5/8	x	6 3/8	1 1/8	7 x 6 3/8
14	x	10	2 1/4	x	9 3/8	1 5/8	10 1/2 x 9 3/8
20	x	14	3 1/4	x	13 3/8	2 1/4	15 1/2 x 13 3/8
28	x	20	3 3/4	x	19 3/8	2 3/4	24 x 19 3/8

Examples of signs are shown in Figs. 1-5.

FIG. 1 (7 x 10)

FIG. 2 (7 x 10)

FIG. 3 (14 x 20)

FIG. 4 (14 x 20)

FIG. 5 (14 x 20)

FIG. 6

(21) LINE ON LIGHT

ES-1.9-34

GENERAL

A "LINE ON" INDICATION IS A SMALL RED LIGHT CONNECTED IN THE SYSTEM CONTROL CIRCUIT SUCH THAT WHEN THE "POWER ON" SWITCH IS ENERGIZED THE RED LIGHT WILL BURN STEADILY.

THE "LINE ON" INDICATING RED LIGHT SHALL BE MOUNTED ON THE CONTROL PANEL AND BE ENERGIZED WHEN OPERATING VOLTAGE IS MADE AVAILABLE TO THE SYSTEM.

DESCRIPTION

A "LINE ON" INDICATING LIGHT THAT COMPLIES WITH THE REQUIREMENTS OF THIS STANDARD IS SHOWN IN THE FOLLOWING EXAMPLE. REFERENCE TO MATERIAL OR EQUIPMENT BY BRAND NAME, CATALOG NUMBER, OR NAME OF MANUFACTURER IS INTENDED TO BE DESCRIPTIVE, NOT RESTRICTIVE, AND IS SOLELY FOR THE PURPOSE OF INDICATING THE QUALITY OF ITEM THAT IS ACCEPTABLE.

FIG. 1

PILOT LIGHT, TRANSFORMER TYPE,
120 VOLTS, 60 HZ, WITH A RED
COLOR CAP ALLEN-BRADLEY,
BULLETIN 800T.

FIG. 2

SAMPLE CONTROL PANEL

ELEMENTARY DIAGRAMS OF TYPICAL CIRCUITS

FIG. 3

FIG. 4

22 SYSTEM ARMED LIGHT

ES-1.9-35

GENERAL

A "SYSTEM ARMED" INDICATION IS A SMALL AMBER LIGHT CONNECTED IN THE SYSTEM CONTROL CIRCUIT SUCH THAT WHEN THE RADIATION SOURCE IS READY TO BE ENERGIZED THE AMBER LIGHT WILL BURN STEADILY.

THE "SYSTEM ARMED" INDICATING AMBER LIGHT SHALL BE MOUNTED ON THE CONTROL PANEL AND BE ENERGIZED WHEN ALL "SYSTEM ON" REQUIREMENTS HAVE BEEN SATISFIED EXCEPT FOR DEPRESSING THE "X-RAY ON" OR "SOURCE EXPOSED" PUSHBUTTON.

DESCRIPTION

A "SYSTEM ARMED" INDICATING LIGHT THAT COMPLIES WITH THE REQUIREMENTS OF THIS STANDARD IS SHOWN IN THE FOLLOWING EXAMPLE. REFERENCE TO MATERIAL OR EQUIPMENT BY BRAND NAME, CATALOG NUMBER, OR NAME OF MANUFACTURER IS INTENDED TO BE DESCRIPTIVE, NOT RESTRICTIVE, AND IS SOLELY FOR THE PURPOSE OF INDICATING THE QUALITY OF ITEM THAT IS ACCEPTABLE.

FIG. 1

PILOT LIGHT, TRANSFORMER TYPE, 120 VOLTS, 60 HZ, WITH AN AMBER-COLOR CAP ALLEN-BRADLEY, BULLETIN 800T.

FIG. 2
SAMPLE CONTROL PANEL

ELEMENTARY DIAGRAMS OF TYPICAL CIRCUITS

FIG. 3

FIG. 4

NOTES:

1. ADD CIRCUIT IN DASHED LINES WHEN NUCLEAR SOURCE IS INSTALLED IN SAME FACILITY AS X-RAY.

(23) SYSTEM ON-STEADY LIGHT

ES-1.9-36

GENERAL

A "SYSTEM ON-STEADY" INDICATION IS A SMALL RED OR MAGENTA LIGHT CONNECTED IN THE SYSTEM CONTROL CIRCUIT SUCH THAT WHEN THE RADIATION SOURCE IS ENERGIZED THE RED OR MAGENTA LIGHT WILL BURN STEADY.

THE "SYSTEM ON-STEADY" INDICATING RED OR MAGENTA LIGHT SHALL BE MOUNTED ON THE CONTROL PANEL AND BE ENERGIZED WHEN X-RAY HIGH VOLTAGE AND/OR SOURCE EXPOSED SYSTEM IS ENERGIZED.

DESCRIPTION

A "SYSTEM ON-STEADY" INDICATING LIGHT THAT COMPLIES WITH THE REQUIREMENTS OF THIS STANDARD IS SHOWN IN THE FOLLOWING EXAMPLE. REFERENCE TO MATERIAL OR EQUIPMENT BY BRAND NAME, CATALOG NUMBER, OR NAME OF MANUFACTURER IS INTENDED TO BE DESCRIPTIVE, NOT RESTRICTIVE, AND IS SOLELY FOR THE PURPOSE OF INDICATING THE QUALITY OF ITEM THAT IS ACCEPTABLE.

FIG. 1

PILOT LIGHT, TRANSFORMER TYPE,
120 VOLTS, 60 HZ, WITH A RED OR
MAGENTA COLOR CAP. ALLEN-BRADLEY
BULLETIN 800T.

FIG. 2
SAMPLE CONTROL PANEL

ELEMENTARY DIAGRAMS OF TYPICAL CIRCUITS

FIG. 3

FIG. 4

24 SYSTEM ON-FLASHING LIGHT

ES-1.9-37

GENERAL

A "SYSTEM ON-FLASHING" INDICATION IS A RED OR MAGENTA* LIGHT CONNECTED IN THE SYSTEM CONTROL CIRCUIT SUCH THAT WHEN THE RADIATION SOURCE IS ENERGIZED THE RED OR MAGENTA LIGHT WILL BE CYCLED ON AND OFF BY A FLASHER UNIT.

THE "SYSTEM ON-FLASHING" INDICATING RED OR MAGENTA LIGHT SHALL BE MOUNTED IN DUAL ARRANGEMENT WITH A LIGHT WHICH IS DESCRIBED IN ENGINEERING STANDARD Y-ES-1.9-38. THIS LIGHT SHALL BE MOUNTED APPROXIMATELY AT EYE LEVEL IN THE WORK AND/OR RADIATION AREA SO AS TO WARN PERSONNEL OF THE EXISTING RADIATION HAZARD. THIS LIGHT WILL BE FLASHING WHILE THE X-RAY CONTACTOR(S) IS CLOSED AND/OR THE RADIOACTIVE SOURCE IS EXPOSED, IF USED. THE FLASHING LIGHT IS REQUIRED ON ALL X-RAY UNITS AND ON ALL SOURCE FACILITIES WHICH ARE ELECTRICALLY ACTUATED.

(*) USE RED LIGHT PENDING REVISION OF ANSI Z53.1-1967 AND HEW MORP 68-14.

DESCRIPTION

A "SYSTEM ON-FLASHING" INDICATING LIGHT THAT COMPLIES WITH THE REQUIREMENTS OF THIS STANDARD IS SHOWN IN THE FOLLOWING EXAMPLE. REFERENCE TO MATERIAL OR EQUIPMENT BY BRAND NAME, CATALOG NUMBER, OR NAME OF MANUFACTURER IS INTENDED TO BE DESCRIPTIVE, NOT RESTRICTIVE, AND IS SOLELY FOR THE PURPOSE OF INDICATING THE QUALITY OF ITEM THAT IS ACCEPTABLE.

INCANDESCENT LIGHT FIXTURE, VAPORTIGHT, FOR WALL MOUNTING ON A FOUR-INCH BOX. FIXTURE SHALL HAVE RED OR MAGENTA GLOBE, WIRE GUARD, AND 100-WATT LAMP. STONCO ELECTRIC PROD. CO. TYPE VW-1G-PG.

REPEAT CYCLE TIMER, CAM ACTUATED, SINGLE SWITCH WITH SPDT CONTACT ACTION, RATED 20 A. AT 125 V. CAM SHAFT SPEED 7-1/2 SEC/REV. CAM TO ACTUATE SWITCH EVERY 90° OF ROTATION. HAYDON SW. AND INSTR. CO. HAYDON SERIES RG21.

ELEMENTARY DIAGRAMS OF TYPICAL CIRCUITS

FIG. 1

FIG. 2

DESCRIPTION

A "SYSTEM ON FLASHING" INDICATING LIGHT FOR USE WITH ANALYTICAL X-RAY EQUIPMENT THAT COMPLIES WITH THE REQUIREMENTS OF THIS STANDARD IS SHOWN IN THE FOLLOWING EXAMPLE. REFERENCE TO MATERIAL OR EQUIPMENT BY BRAND NAME, CATALOG NUMBER, OR NAME OF MANUFACTURER IS INTENDED TO BE DESCRIPTIVE, NOT RESTRICTIVE, AND IS SOLELY FOR THE PURPOSE OF INDICATING THE QUALITY OF ITEM THAT IS ACCEPTABLE. (REF. UCC-ND ENGR. DWGS. C-E-31158 AND C-E-31159.)

FIG. 1 ELEMENTARY WIRING DIAGRAM

PCB-1

- T1 FILAMENT TRANSFORMER, PRI. 117 VOLTS, 60 CYCLES, SEC. 6.3 VOLTS CT AT 1.2 AMPS. THORDARSON 21F08.
- D1-D6 DIODE, SILICON, TEXAS 1N2071.
- Q1-Q2 TRANSISTOR, GERMANIUM, PNP, 2N2084 AMPEREX.
- Q3-Q5 TRANSISTOR, TEXAS 2N526.
- LF DRY REED RELAY, DPDT CONTACTS RATED 10 VA AT 0.5 AMP COIL VOLTS 6 VDC, COIL RESISTANCE 50 OHMS, MAGNEEED W103PCX-5, MAGNECRAFT ELECT. CO.
- C1-C2 CAPACITOR, FIXED, DRY ELECTROLYTIC, 1000 MFD, 15 VDC, MALLORY.
- C3-C4 CAPACITOR, FIXED, DRY ELECTROLYTIC, 50 MFD, 50 VDC, MALLORY.
- R1-R4 RESISTOR, COMP. CARBON, FIXED, 1/2 WATT, 2400 OHMS, ALLEN-BRADLEY.
- R5-R6 RESISTOR, COMP. CARBON, FIXED, 1 WATT, 27 OHMS, ALLEN-BRADLEY.
- R7-R8 RESISTOR, COMP. CARBON, FIXED, 1/2 WATT, 27,000 OHMS, ALLEN-BRADLEY.
- R9 RESISTOR, COMP. CARBON, FIXED, 1/2 WATT, 5100 OHMS, ALLEN-BRADLEY.
- R10 RESISTOR, COMP. CARBON, FIXED, 1/2 WATT, 7.5 OHM, ALLEN-BRADLEY.
- LT1-LT2 PILOT LIGHT ASSEMBLY, RED LUCITE LENS, FOR T3-1/4 MBB #47 LAMP, E. F. JOHNSON CO.
- H1-H2 SONALERT ELECTRONIC AUDIBLE SIGNAL, 2800 HZ, 6-28 VOLTS D.C., MALLORY SC628.
- SW1 SWITCH, TOGGLE, DPDT, 125 VOLT, 6 AMP.
- TB TERMINAL BOARD, 12 PT.

FIG. 2 ELEMENTARY DIAGRAM OF TYPICAL CIRCUIT

②⑤ VSD ON/SOURCE EXPOSED-FLASHING LIGHT

ES-1.9-38

GENERAL

A "VSD ON OR SOURCE EXPOSED-FLASHING" INDICATION IS A RED OR MAGENTA* LIGHT CONNECTED IN THE SYSTEM CONTROL CIRCUIT SUCH THAT WHEN THE RADIATION SOURCE IS ENERGIZED OR THE RADIOACTIVE SOURCE EXPOSED THE RED OR MAGENTA LIGHT WILL BE CYCLED ON AND OFF BY A FLASHER UNIT.

THE "VSD ON OR SOURCE EXPOSED - FLASHING" INDICATING RED OR MAGENTA LIGHT SHALL BE MOUNTED IN DUAL ARRANGEMENT WITH A LIGHT WHICH IS DESCRIBED IN ENGINEERING STANDARD ES-1.9-37. THIS LIGHT SHALL BE MOUNTED APPROXIMATELY AT EYE LEVEL IN THE WORK AND/OR RADIATION AREA SO AS TO WARN PERSONNEL OF THE EXISTING RADIATION HAZARD. THIS LIGHT WILL BE FLASHING WHILE THE VSD IS ENERGIZED AND/OR BY AN UP-SCALE READING OF A RADIATION MONITOR. THIS FLASHING LIGHT IS REQUIRED ON ALL X-RAY UNITS AND ON ALL SOURCE FACILITIES EQUIPPED WITH A RADIATION MONITOR.

DESCRIPTION

A "VSD ON OR SOURCE EXPOSED-FLASHING" INDICATING LIGHT THAT COMPLIES WITH THE REQUIREMENTS OF THIS STANDARD IS SHOWN IN THE FOLLOWING EXAMPLE. REFERENCE TO MATERIAL OR EQUIPMENT BY BRAND NAME, CATALOG NUMBER, OR NAME OF MANUFACTURER IS INTENDED TO BE DESCRIPTIVE, NOT RESTRICTIVE, AND IS SOLELY FOR THE PURPOSE OF INDICATING THE QUALITY OF ITEM THAT IS ACCEPTABLE.

FIG. 1

INCANDESCENT LIGHT FIXTURE VAPORTIGHT
FOR WALL MOUNTING ON A FOUR-INCH BOX.
FIXTURE SHALL HAVE RED OR MAGENTA GLOW,
WIRE GUARD, AND 100-WATT LAMP. STONCO
ELECTRIC PRODUCT CO. TYPE VW-IG-PG.

(*) USE RED LIGHT PENDING REVISION OF
ANSI Z53.1-1967 AND HEW MORP 68-14.

FIG. 2

FIG. 3

ELEMENTARY DIAGRAMS OF TYPICAL CIRCUITS CONT.

FIGURE 3

FIGURE 4

(FOR INSTALLATION WITH MORE THAN TWO SETS OF 120 VOLT, 100 WATT FLASHING LAMPS.)

DESCRIPTION

A "VSD ON OR SOURCE EXPOSED" FLASHING INDICATING LIGHT FOR USE WITH ANALYTICAL X-RAY EQUIPMENT THAT COMPLIES WITH THE REQUIREMENTS OF THIS STANDARD IS SHOWN IN THE FOLLOWING EXAMPLE. REFERENCE TO MATERIAL OR EQUIPMENT BY BRAND NAME, CATALOG NUMBER, OR NAME OF MANUFACTURER IS INTENDED TO BE DESCRIPTIVE, NOT RESTRICTIVE, AND IS SOLELY FOR THE PURPOSE OF INDICATING THE QUALITY OF ITEM THAT IS ACCEPTABLE. (REF. UCC-ND ENGR. DWGS. C-E-31158 AND C-E-31159.)

FIG. 1 ELEMENTARY WIRING DIAGRAM
PCB-1

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D1-D6 DIODE, SILICON, TEXAS 1N2071.
Q1-Q2 TRANSISTOR, GERMANIUM, PNP, 2N2084 AMPEREX.
Q3-Q5 TRANSISTOR, TEXAS 2N526.
LF DRY REED RELAY, DPDT CONTACTS RATED 10 VA AT 0.5 AMP COIL VOLTS 6 VDC, COIL RESISTANCE 50 OHMS, MAGNEEED W103PCX-5, MAGNECRAFT ELECT. CO.
C1-C2 CAPACITOR, FIXED, DRY ELECTROLYTIC, 1000 MFD, 15 VDC, MALLORY.
C3-C4 CAPACITOR, FIXED, DRY ELECTROLYTIC, 50 MFD, 50 VDC, MALLORY.
R1-R4 RESISTOR, COMP. CARBON, FIXED, 1/2 WATT, 2400 OHMS, ALLEN-BRADLEY.
R5-R6 RESISTOR, COMP. CARBON, FIXED, 1/2 WATT, 51 OHMS, ALLEN-BRADLEY.
R7-R8 RESISTOR, COMP. CARBON, FIXED, 1/2 WATT, 27,000 OHMS, ALLEN-BRADLEY.
R9 RESISTOR, COMP. CARBON, FIXED, 1/2 WATT, 5100 OHMS, ALLEN-BRADLEY.
R10 RESISTOR, COMP. CARBON, FIXED, 1/2 WATT, 2.5 OHM, ALLEN-BRADLEY.
LT1-LT2 PILOT LIGHT ASSEMBLY, RED LUCITE LENS, FOR T3-1/4-MBB #47 LAMP, E. F. JOHNSON CO.
H1-H2 SONALERT ELECTRONIC AUDIBLE SIGNAL, 2800 HZ, 6-28 VOLTS D.C., MALLORY SC628.
SW1 SWITCH, TOGGLE, DPDT, 125 VOLT, 6 AMP.
TB TERMINAL BOARD, 12 PT.

FIG. 2 - ELEMENTARY DIAGRAM OF TYPICAL CIRCUIT

(26) SHUTTER OPEN-FLASHING LIGHT

ES-1.9-39

GENERAL

A "SHUTTER OPEN--FLASHING" INDICATION IS A RED OR MAGENTA* LIGHT CONNECTED IN THE SYSTEM CONTROL CIRCUIT SUCH THAT WHEN THE SHUTTER IS OPEN AND THE RADIATION SOURCE IS ENERGIZED OR THE RADIOACTIVE SOURCE EXPOSED THE RED OR MAGENTA LIGHT WILL BE CYCLED ON AND OFF BY A FLASHER UNIT.

THE "SHUTTER OPEN--FLASHING" INDICATING RED OR MAGENTA LIGHT SHALL BE MOUNTED IN A NEMA ONE ENCLOSURE IN DUAL ARRANGEMENT WITH A RED OR MAGENTA LIGHT WHICH WILL OPERATE AS DESCRIBED IN ENGINEERING STANDARD ES-1.9-38. THIS LIGHT SHALL BE MOUNTED APPROXIMATELY AT EYE LEVEL IN THE RADIATION AREA SO AS TO WARN PERSONNEL OF THE EXISTING RADIATION HAZARD. THIS LIGHT WILL BE FLASHING WHILE THE SHUTTER IS OPEN AND THE X-RAY CONTACTOR(S) IS CLOSED AND/OR THE RADIOACTIVE SOURCE IS EXPOSED.

DESCRIPTION

A "SHUTTER OPEN--FLASHING" INDICATING LIGHT THAT COMPLIES WITH THE REQUIREMENTS OF THIS STANDARD IS SHOWN IN THE FOLLOWING EXAMPLE. REFERENCE TO MATERIAL OR EQUIPMENT BY BRAND NAME, CATALOG NUMBER, OR NAME OF MANUFACTURER IS INTENDED TO BE DESCRIPTIVE, NOT RESTRICTIVE, AND IS SOLELY FOR THE PURPOSE OF INDICATING THE QUALITY OF ITEM THAT IS ACCEPTABLE.

FIG. 1

TWO PILOT LIGHTS, TRANSFORMER TYPE, 120 VOLTS, 60 HZ, WITH RED OR MAGENTA COLOR CAP, MOUNTED IN NEMA ONE ENCLOSURE. ALLEN-BRADLEY BULLETIN 800T.

(*) USE RED LIGHT PENDING REVISION OF ANSI Z53.1-1967 AND HEW MORP 68-14.

ELEMENTARY DIAGRAMS OF TYPICAL CIRCUITS

FIG. 2

FIG. 3

27 SHUTTER CLOSED-STEADY LIGHT

ES-1.9-40

GENERAL

A "SHUTTER CLOSED--STEADY LIGHT" INDICATION IS A SMALL GREEN LIGHT CONNECTED IN THE SYSTEM CONTROL CIRCUIT SUCH THAT WHEN THE SHUTTER IS CLOSED ON THE RADIATION SOURCE THE GREEN LIGHT WILL BURN STEADY.

THE "SHUTTER CLOSED" INDICATING GREEN LIGHT SHALL BE MOUNTED ON THE CONTROL PANEL.

DESCRIPTION

A "SHUTTER CLOSED" INDICATING LIGHT THAT COMPLIES WITH THE REQUIREMENTS OF THIS STANDARD IS SHOWN IN THE FOLLOWING EXAMPLE. REFERENCE TO MATERIAL OR EQUIPMENT BY BRAND NAME, CATALOG NUMBER, OR NAME OF MANUFACTURER IS INTENDED TO BE DESCRIPTIVE, NOT RESTRICTIVE, AND IS SOLELY FOR THE PURPOSE OF INDICATING THE QUALITY OF ITEM THAT IS ACCEPTABLE.

FIG. 1

PILOT LIGHT, TRANSFORMER TYPE, 120 VOLTS, 60 HZ, WITH A GREEN COLOR CAP. ALLEN-BRADLEY, BULLETIN 800T.

FIG. 2
SAMPLE CONTROL PANEL

ELEMENTARY DIAGRAMS OF TYPICAL CIRCUITS

FIG. 3

FIG. 4

(28) X-RAY OFF/SOURCE SHIELDED LIGHT

ES-1.9-41

GENERAL

AN "X-RAY OFF OR SOURCE SHIELDED" INDICATION IS A SMALL GREEN LIGHT CONNECTED IN THE SYSTEM CONTROL CIRCUIT SUCH THAT WHEN THE RADIATION SOURCE IS DE-ENERGIZED THE GREEN LIGHT WILL BURN STEADY.

THE "X-RAY OFF OR SOURCE SHIELDED" INDICATING GREEN LIGHT SHALL BE MOUNTED ON THE CONTROL PANEL AND BE ENERGIZED WHEN THE X-RAY HIGH VOLTAGE IS OFF OR SOURCE IS SHIELDED.

DESCRIPTION

AN "X-RAY OFF OR SOURCE SHIELDED" INDICATING LIGHT THAT COMPLIES WITH THE REQUIREMENTS OF THIS STANDARD IS SHOWN IN THE FOLLOWING EXAMPLE. REFERENCE TO MATERIAL OR EQUIPMENT BY BRAND NAME, CATALOG NUMBER, OR NAME OF MANUFACTURER IS INTENDED TO BE DESCRIPTIVE, NOT RESTRICTIVE, AND IS SOLELY FOR THE PURPOSE OF INDICATING THE QUALITY OF ITEM THAT IS ACCEPTABLE.

FIG. 1

PILOT LIGHT, TRANSFORMER TYPE, 120 VOLTS, 60 HZ, WITH A GREEN COLOR CAP. ALLEN-BRADLEY, BULLETIN 800T.

FIG. 2
SAMPLE CONTROL PANEL

FIG. 3

NOTES:

1. ADD CIRCUIT IN DASHED LINES WHEN NUCLEAR SOURCE IS INSTALLED IN SAME FACILITY AS X-RAY.

FIG. 4

30 BELL

ES-1.9-43

GENERAL

A BELL IS AN ELECTRICAL NOISE SIGNAL DEVICE CONNECTED IN THE SYSTEM CONTROL CIRCUIT SUCH THAT A WARNING WILL BE GIVEN BEFORE THE RADIATION SOURCE CAN BE ENERGIZED.

A BELL SHALL BE MOUNTED ON THE INSIDE OF THE VAULT, ROOM, OR ENCLOSURE AND SHALL BE ENERGIZED FOR FIVE SECONDS WHEN THE DOOR OR OTHER ACCESS TO THE AREA IS CLOSED. THIS SIGNAL WILL SERVE AS THE FIRST WARNING TO ANY PERSONNEL IN SUCH AN AREA THAT THE AREA SHOULD BE EVACUATED, OR THE SCRAM SWITCH ACTIVATED TO PREVENT ENERGIZING THE X-RAY UNIT.

DESCRIPTION

A BELL THAT COMPLIES WITH THE REQUIREMENTS OF THIS STANDARD IS SHOWN IN THE FOLLOWING EXAMPLE. REFERENCE TO MATERIAL OR EQUIPMENT BY BRAND NAME, CATALOG NUMBER, OR NAME OF MANUFACTURER IS INTENDED TO BE DESCRIPTIVE, NOT RESTRICTIVE, AND IS SOLELY FOR THE PURPOSE OF INDICATING THE QUALITY OF ITEM THAT IS ACCEPTABLE.

FIG. 1

BELL, VIBRATING TYPE, FOUR-INCH INTERIOR MODEL, SUITABLE FOR MOUNTING ON STANDARD FOUR-INCH SQUARE BOX. BELL TO OPERATE ON 120 VOLTS A.C., 60 HZ. FEDERAL SIGN AND SIGNAL CORPORATION, CLASS 500, MODEL 504N.

ELEMENTARY DIAGRAMS OF TYPICAL CIRCUITS

FIG. 2

FIG. 3

33 BARRICADES**ES-1.9-46****General**

A barricade is a physical obstruction for the purpose of keeping personnel away from a radiation area. Barricades will be used when it is impractical or impossible to enclose the radiation producing equipment in a vault.

Barricades are divided into two categories: light and medium. Light barricades consist of ropes or chains with appropriate signs attached and may be used when the level of exposure is less than 100 mrem/hr. or on a temporary basis at higher levels if an operator is in attendance at all times. Medium barricades consist of fences or partitions which are more substantial than light barricades and may be used when the radiation level exceeds 100 mrem/hr. and the equipment is left unattended. Where an electrical interlock is required by the safety features review committee to be used with a medium barricade, Reference ES-1.9-25 should be used in conjunction with this reference.

Examples of light and medium barricades are shown in Figures 1 and 2.

**ROPE BARRICADE
FIG. 1**

Notes

- (1) Industrial Products Co. "Polyrope", 5/16" dia., 2 strands yellow, 1 strand magenta, Cat. #10R.
- (2) Reference ES-1.9-33 for signs.

**FENCE BARRICADE
FIG. 2**

Notes

- (1) Reference ES-1.9-33 for signs.

34 PADLOCKS**ES-1.9-47****General**

A padlock is a key operated mechanical device for fastening a door, electrical disconnect switch, shield cover, drawer, etc.

Padlocks will be used to assure that unauthorized persons cannot operate X-ray equipment or expose certain sources. They will be used when equipment or sources are in storage and when it is desirable to lock out the main power disconnect switch on X-ray equipment.

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