

EVALUATION OF THE RF SCR CABINET DESIGN AND PROPOSED SOLUTION PHILOSOPHY

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1. INTRODUCTION

On two separate occasions, electrical faults in the SCR cabinet of the high-voltage rf power supplies created a momentary pressure buildup, forcing the doors of the cabinet to open violently and unexpectedly. A safety review resulting from these incidents documented another deficiency that allowed material accidentally dropped from the mezzanine above to enter the SCR cabinet. Other concerns sighted during the inspection were the location and presence of water in the cabinet and the questionable installation of the 1400-V feed to the cabinet. Because of the safety implications involved, a review of the cabinet's design and a recommended corrective action was necessitated.

2. CABINET CONSTRUCTION

The rf SCR cabinets are standard 90" x 72" x 36" free-standing two-door single-access Bulletin A-30 Hoffman enclosures (fig. 1). The unmodified cabinets are NEMA Type 12 intended for indoor use primarily to provide a degree of protection against dust, falling dirt and dripping non-corrosive liquids. The cabinets are, however, modified to accommodate various equipment. There are five fans for forced air cooling requiring three 9" holes on top and two 9" holes on the right side. A kirk-keyed safety disconnect switch is mounted on the left side of the cabinet. Equipment cooling water is brought in through two 1.5" openings in the top. The resulting enclosure is NEMA Type 1 which provides a degree of protection against contact with the enclosed equipment.

After the first incident, a safety cable was placed across the doors to limit their travel to an acceptable distance during a fault condition. Unfortunately, the safety cables were left unhooked, and we were not able to validate their function at the time of the second fault.

Three sets of 4-4/0 cables and a 4/0 ground cable enter the rear of the cabinet via a 8" Hoffman lay-in NEMA Type 1 wireway and connect directly to a kirk-key interlocked safety disconnect switch. From there the cables are tied to three sets of two paralleled fuses (1100 amp rating) and

then to the 1200-amp vacuum breaker. The load side of the vacuum breaker is connected to the water-cooled SCR stacks and then goes outside to the transformer/rectifier equipment.

3. IDENTIFIED PROBLEMS AND CORRECTIVE ACTION OPTIONS

- **Doors Opening During Fault Conditions**

The major concern with the construction of the cabinet is the violent and uncontrolled opening of the doors during an electrical fault in the cabinet. There are two methods of corrective action being investigated. The first method leaves the doors basically as they are and relies on the safety cables to limit movement of the doors to an acceptable distance. The second method would involve removal of a large portion of the top of the cabinet and installation of an “umbrella” over it.

The first fault was caused by a loose wire falling into an adjacent phase of the 1400 volts. Barriers were installed to prevent similar incidents from occurring. The second fault was caused by the ground stick being left on C phase of the 1400 volts. The ground stick has now been moved to the outside of the cabinet. With these modifications in place, the potential of a fault occurring again has been greatly reduced. With the chance of another fault occurring significantly reduced, the existing doors and safety cable could be left in place as the pressure relief system. This option requires the least amount of reconstruction but still presents the potential for personal injury caused by the doors swinging out, albeit a limited amount.

The second option would remove the top of the cabinet and add an umbrella type of cover over the cabinet, thus providing the means for pressure relief. Instituting this option would also keep foreign material from inadvertently entering the cabinet from above, a problem discussed in more detail below. Along with this modification, the door latches could be reinforced to keep the doors from blowing open. This would reduce the risk of injury when standing near the doors when the supplies are operating.

In either case, it was also suggested that the fuses be moved outside the cabinet so all incoming power to the cabinet will be current limited.

- **Fan Openings in the Top and Side of the Cabinet**

A concern pointed out during a safety walkthrough was the ability to drop objects or spill liquids into the SCR cabinet from the mezzanine. Three 9” cooling fan openings with only finger guards over the blades are cut into the top of the cabinet. With these cabinets directly under the mezzanine, people walking overhead could drop, kick, or spill foreign materials directly into the 1400-V components. As discussed above, an umbrella with the fans incorporated into it, could be made to cover the top of the cabinet. The two other fan openings in the side of the cabinet could also be enclosed in a box with an open bottom to provide air flow.

- **Water in the Cabinet**

Although water is required to cool the SCRs, the amount of water-related hardware inside the cabinet could be reduced, thus reducing the possibility of a leak causing a fault. Additionally, a small water leak in the cabinet, not detected by the flow switches, will fill the bottom of the cabinet with six inches of water and could cause an electrical fault. A drain hole could be installed at the low point of the cabinet to allow any leaks to drain, and a moisture-sensing circuit could be incorporated in the power supply interlock circuit to alert Operations of a potential problem.

- **Cable Feedthrough**

The input cables enter the cabinet via an 8” Hoffman NEMA Type 1 lay-in wireway. This inadequate installation could very easily be damaged by a small lift truck. An installation using more rigid material and incorporating the fuses in the new installation could prevent another fault scenario.

4. CONTACTS

Industrial Enclosure Corp. / John Palmer / President

1-630-898-0400

Industrial Enclosures built the power supply converter cabinets for the storage ring. Mr. Palmer visited the site and identified the cabinets as Hoffman built enclosures. His opinion is that the safety cable across the doors appears to be an adequate pressure relief system.

KGA Engineering Company, Inc. / Gene Wojtas / Sales Representative

1-847-367-5700

Mr. Wojtas is the sales representative for Hoffman Engineering Company. He responded immediately and verified the cabinets were indeed Hoffman enclosures. He took pictures and

measurements of the cabinet, forwarded them to Hoffman engineers, and had them contact me with their findings.

Hoffman Engineering Company / Mike Dwyer / Sr. Applications Mgr.

1-612-422-2868

Mr. Dwyer was the engineer who reviewed the pictures and made the recommendations to remove the top of the cabinet, move the fuses outside the cabinet, and retain the safety cable feature as a back-up.

Siemens (Atlanta Office) / John Patrick / Electrical Engineer.

1-770-496-8659

Mr. Patrick was consulted by Mr. Dwyer and concurred with his findings. He also suggested testing the cabinets after the modifications were implemented. Kearney Laboratories was suggested as a local test facility. He suggested looking at UL 489 Molded Case Circuit Breakers and Circuit Breaker Enclosures as a reference.

Kearney Laboratories (McCook, IL) / Jack Kise / Lab Manager

1-708-458-6400

Mr. Kise has the capability to simulate a fault similar to ours in a controlled and monitored environment using our cabinet.

5. SUMMARY

The main objective in modifying the SCR cabinet is to vent, not contain, the pressure build-up in the cabinet during a fault. In conversations I've had with various people, I found that there are no codes or standards that apply directly to this type of cabinet assembly and that these types of cabinets are built by experience. Based on the information I have gathered, I believe the following modifications should be implemented (use fig. 2 as a reference):

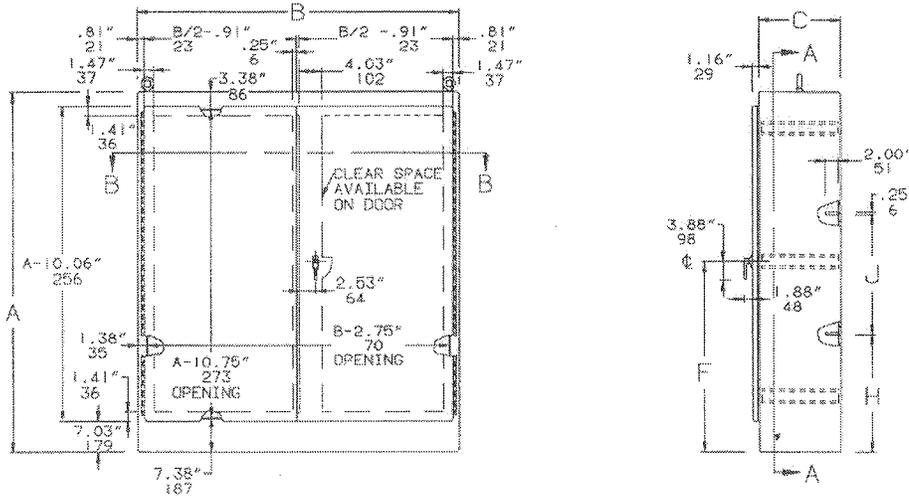
- 1) Increase the openings in the top of the cabinet to maximize the size of the vent area. The fans must remain and be incorporated into the design, maintaining air flow across the components.
- 2) Add an "umbrella" over the cabinet, maintaining a vent area equal to the area of the cabinet top. This should provide adequate pressure relief and keep anything from dropping into the cabinet from the mezzanine. A screen must be installed around the perimeter of the umbrella to prevent access to equipment in the cabinet. An additional

enclosure must also be installed over the fans on the side of the cabinet, keeping an opening in the bottom of the enclosure for air flow.

- 3) Move the fuses and mounting assembly outside the cabinet and incorporate them into an incoming cable enclosure. This enclosure could be a 36" x 24" x 12" Hoffman single door Type 12 enclosure attached to the back of the existing cabinet. Remove the wireway and install rigid conduit from the floor to this enclosure. Interlock the door with the 13.2-kV load interrupter so if the door is opened the load interrupter will open.
- 4) Strengthen the door latching mechanism to keep the doors from opening during a fault.
- 5) Relocate the water hardware in another Hoffman enclosure outside the cabinet. This enclosure could have a hinged window-door enabling monitoring of the flow switches and electronics online.
- 6) Retain the safety cable across the doors.
- 7) Test the final design to verify all design criteria have been met. Kearney Laboratories can reproduce a fault based on our power system parameters for about \$4,000. After a few meetings with the engineer to coordinate the testing, a month lead time, and any mechanical instrumentation we need, the modified cabinet can be shipped to the lab and tested in a day or two.
- 8) Properly label enclosures, noting purpose and hazards.
- 9) Revise all cabinet entry procedures.

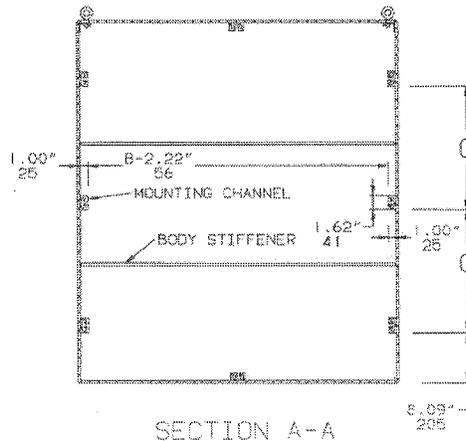
I will continue to contact other people for additional information and suggestions and incorporate the pertinent ones into the final design.

Two-Door Single Access



C2489-1

- NOTE:
- Four lifting eyes are furnished if C = 30.06 (764) or more.
 - See pages 543, 547, and 550 for section views A-A and B-B showing accessories.
 - Removable 12.00 x 12.00 (305 x 305) data pocket.



Inch
Millimeter

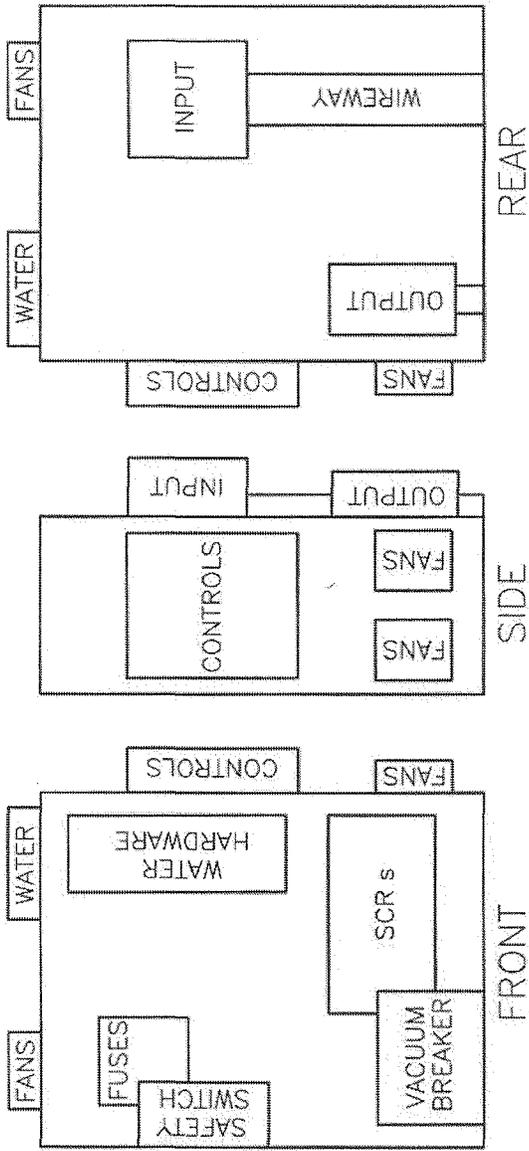
Standard Sizes Two-Door Single Access Free-Standing Type I2 Enclosures

Enclosure Catalog Number	Enclosure Size A x B x C		F		G		H		J	
	inch	(millimeter)	inch	(mm)	inch	(mm)	inch	(mm)	inch	(mm)
A-604818FSD	60.06 x 48.06 x 18.06	(1526 x 1221 x 472)	32.03	(814)	23.12	(587)	19.88	(505)	20.03	(509)
A-724818FSD	72.06 x 48.06 x 18.06	(1830 x 1221 x 472)	38.03	(966)	29.12	(740)	23.88	(607)	24.03	(610)
A-726018FSD	72.06 x 60.06 x 18.06	(1830 x 1526 x 472)	38.03	(966)	29.12	(740)	23.88	(607)	24.03	(610)
A-727218FSD	72.06 x 72.06 x 18.06	(1830 x 1830 x 472)	38.03	(966)	29.12	(740)	23.88	(607)	24.03	(610)
A-904820FSD	90.06 x 48.06 x 20.06	(2286 x 1221 x 510)	47.03	(1195)	38.12	(968)	29.88	(759)	30.03	(763)
A-907220FSD	90.06 x 72.06 x 20.06	(2286 x 1830 x 510)	47.03	(1195)	38.12	(968)	29.88	(759)	30.03	(763)
A-724824FSD	72.06 x 48.06 x 24.06	(1830 x 1221 x 611)	38.03	(966)	29.12	(740)	23.88	(607)	24.03	(610)
A-726024FSD	72.06 x 60.06 x 24.06	(1830 x 1526 x 611)	38.03	(966)	29.12	(740)	23.88	(607)	24.03	(610)
A-727224FSD	72.06 x 72.06 x 24.06	(1830 x 1830 x 611)	38.03	(966)	29.12	(740)	23.88	(607)	24.03	(610)
A-907224FSD	90.06 x 72.06 x 24.06	(2286 x 1830 x 611)	47.03	(1195)	38.12	(968)	29.88	(759)	30.03	(763)
A-726036FSD	72.06 x 60.06 x 36.06	(1830 x 1526 x 916)	38.03	(966)	29.12	(740)	23.88	(607)	24.03	(610)
A-907236FSD	90.06 x 72.06 x 36.06	(2286 x 1830 x 916)	47.03	(1195)	38.12	(968)	29.88	(759)	30.03	(763)

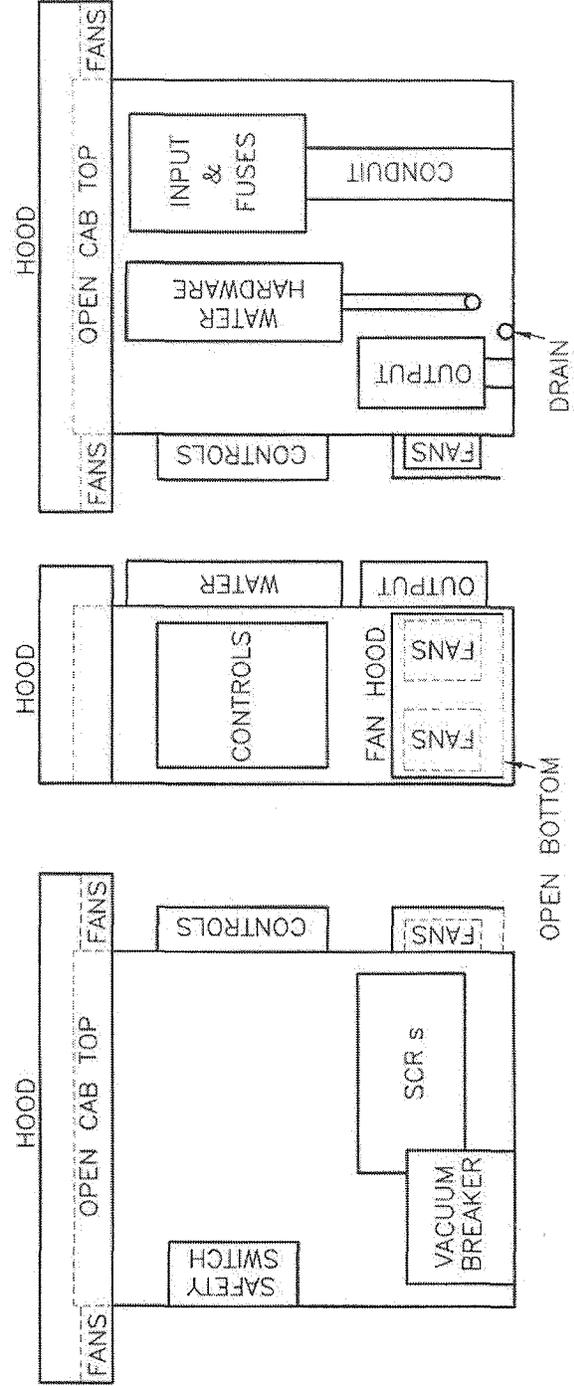
Millimeter dimensions () are for reference only; do not convert metric dimensions to inch.

fig.1

Enclosure CAD drawing, courtesy Hoffman Engineering.



EXISTING



PROPOSED

Fig. 2