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TO: S WARKALA
FROM: C NEUMEYER
SUBJECT: IE POWER DESIGN REVIEW RESULTS AND RELEASE FOR FABRICTION

S Ramakrishan and the writer visited IE Power, Inc., on 23 March for the purposes of a plant tour and design review.

The review was successful.

Therefore, in accordance with the specification, please authorize IE Power (in writing) that they may proceed with fabrication. In addition, please notify them of the following items.

- 1) Minutes of design review meeting and action items (including PPPL responses) are attached. IE Power shall follow up with their action items, *including a revision to their design document.*
- 2) IE Power shall, in accordance with the specification, furnish biweekly progress reports.

Cc: M Ono S Ramakrishnan A Von Halle M Williams

IE Design Review Meeting Notes

- 1) PPPL to indicate incoming and outgoing cable lug hole spacing. → *See post meeting item*
- 2) Gland plate centerlines to be relocated directly over bus bar centers.
- 3) Incoming control wiring to be segregated behind insulating panels.
- 4) Revised cabined weight 4350 lbs.
- 5) PPPL to indicated limits on fork lift spacing and thickness x width of forks.
- 6) Third beam to be added under cabinet to better distribute load. → *See post meeting item*
- 7) Cooling water connections to be located for bottom/side entry, recessed within cabinet and accessible via removable plate.
- 8) Kirk Key logic should release key only when input disconnect switch open and cap discharge switch closed via removal of motive power source to discharge switch. PPPL to provide Kirk Key logic diagram and indicate PPPL vs. IE scope of work. → *See post meeting item*
- 9) Only front panel meter required shall be for the cap bank voltage.
- 10) PPPL to utilize only single pole grounding in SDS to eliminate short circuit condition on cap bank. This will facilitate fusing.
- 11) Input DCCT to be 1kA
- 12) Additional resistance of 1-2mOhm is foreseen for series inductor and internal cables.
- 13) IE Power shall reconfigure discharge switch/resistor to three parallels to increase redundancy. Temperature sensor on resistor to be provided.
- 14) Hipot shall be to ground, not across IGBTs.
- 15) All insulating breaks associated with control/firing circuits shall be included in the hipot test.
- 16) Hydrostat test shall be $1.5 \times \text{operating pressure} = 1.5 \times 120 = 180$ psi minimum.
- 17) 80 microhenries and adjustable resistance will be available for dummy load.
- 18) Water circuit to be changed from 3 parallels to 6 parallels to suit lower differential water pressure.
- 19) Referring to PPPL comments on drawings: C1..twisted pair has been marked up. C2..will provide cross-references on drawings. C3..pins 1 & 14 of J1 are outputs. These will be relocated to the top two terminals of the block. C4..Vref input will be via isolated inputs AD215 Analog Devices. C5..will be changed from Vd to Vdc. C6..signals will be added to D-14781.
- 20) IE will add a pull-down resistor for Vref.
- 21) PPPL shall clarify details of Permissive and Enable signal implementation. Probably the Permissive will be a contact closure and the Enable will be an open collector. → *See post meeting item*
- 22) Load-open detection is not required.
- 23) Remote enable and reset signals shall be applied simultaneously to all three subunits; individual sub-unit signals are not required. → *See post meeting item*
- 24) Tin plated joints are acceptable to PPPL.
- 25) IE to send control circuit drawings to PPPL when they are ready.
- 26) Damper RC circuits to be retained but values TBD until testing.

27) IE to revise design report and forward to PPPL.

28) Need separate ground cable connection points for disconnect switch compartment and main compartment.

Post Meeting Items

1) In prior correspondence, PPPL noted...

“Because of the low resistance of the PPPL load, the IR drop will very low (3333 A * 20mOhm = 66V max, which is only 6.6% duty cycle. Most operations will be performed at very low duty cycle. Will the sawtooth control scheme be sufficiently accurate at low duty cycles?”

The IE response was...

“ In our experience, the sawtooth control scheme is adequate for narrow pulse width required with PPPL load (BNL load is very similar to BNL/SNS load). On the other hand, in BNL/SNS unit we have encountered the problems due to asymmetry in turn-on/turn-off times of IGBT switches. To solve this problem, we have devised unique circuit techniques and this information will be provided in the design report.”

This point was briefly discussed at the design review. However, a more detailed elaboration, including supporting analysis, needs to be included in the design report as previously promised.

2) PPPL response to meeting item 1)

The incoming (bottom entry) power cables from the PPPL equipment to the disconnect switch compartment are 2-1/c 500MCM, 5kV shielded power cables (one conductor to (+) bus and one conductor to (-) bus). The outer diameter of the cable is 1.25”. The cable lug is Burndy YA34-2N. See Burndy website...

<http://ecatalog.fciconnect.com/fci/datasheet.asp?PN=YA342N&FAM=509>

Wire Size	500 kcmil
Stud Hole Size	1/2”
Stud Hole Spacing	1-3/4”
Barrel Length	Long Barrel
Tongue Angle	Straight
Tongue Width	1.52”

The outgoing (top entry) power cables from the SPA to the PPPL equipment are 3-4/c 500MCM, 600V power cables, one 4/c cable from each sub-unit (two parallel conductors to each sub-unit (+) bus and two parallel conductors to each sub-unit (-) bus). The outer diameter of the cable is 2.5”. Cable lug is same as above for incoming cables.

3) PPPL response to meeting item 5)

Note that PPPL has to perform several lifting and moving operations at the site in addition to the operations that may be necessary during shipment. Most of these operations will not utilize a fork lift. Considering this, please arrange to ship the equipment on an appropriate pallet, and change the spacing between the tubes to 60" center to center instead of 32" (ref. IE drawing C14782). With this spacing, and the third beam at the center (see meeting item 6)) the floor loading will be within appropriate limits.

4) PPPL response to meeting item 8)

IE Power shall supply a Kirk Lock/Key which shall be released when the cap bank discharge switch is closed and its motive power has been removed. SPA rear access doors (3) and disconnect switch compartment door (1) shall utilize Kirk Locks/Keys (total of four (4)) to be supplied by PPPL but mounted by IE Power. These locks and keys will be used in conjunction with other locks and keys in PPPL equipment to ensure that the SPA is positively de-energized prior to entering PPPL equipment and that PPPL equipment is positively de-energized prior to entering the SPA. The SPA disconnect switch itself need not be interlocked by a Kirk Key, only the door to the disconnect switch enclosure. We assume that that the control (front) compartments of the SPA can be opened any time without exposing hazards above 120VAC.

5) Preference on Input Disconnect Switch

PPPL would prefer that the input disconnect switch be a double pole double throw 600A switch, instead of the ABB switch proposed by IE Power. In one position the switch connects the DC source to the SPA. In the other position it disconnects the SPA from the source and connects each terminal of the SPA to ground. This is necessary to provide a safety ground when accessing the SPA. A recommended switch is Filnor Catalog# A-7726.

6) PPPL response to meeting item 21)

For the enable signal, since fast response is important, an optocoupler (H11N1 (<http://www.fairchildsemi.com/pfPrint/H1/H11N1-M.html>) or equivalent) shall be provided.

For the permissive signal, PPPL will provide a 125VDC (+/- 10%) signal. Signal present ($V \geq$ half nominal voltage) shall correspond to the "permissive" condition, signal absent ($V <$ half nominal voltage) shall correspond to the "not-permissive" condition.

7) Clarification on meeting item 23)

PPPL now desires (as shown on the IE drawings at the review) to retain one enable signal per sub-unit (total 3) instead of one per the entire SPA.

However, as agreed at the meeting, only one reset signal is required for the SPA (although three could be provided if more convenient). This signal will be a normally open, momentary closed, optocoupler with the following characteristics....

- Capable of switching 28 vdc at 16 milliamps
- Nominal on-time is 300 milliseconds
- Von less than 0.5 volts at 16 ma
- Off-State leakage current 30 microamps (max) at 28 v

8) Clarification on “Fault Not” Signal

Per specification paragraph 3.2.4.3.2, PPPL requires a “Fault Not” signal. This signal is not shown on IE C14784, unless it is the equivalent of the “PSON” signal shown. IE Power needs to clarify this point. In any case, the characteristics of the PPPL input device for this signal are as follows (two modes are available to choose from)...

24 vdc mode:

Input ON voltage: 20 to 30 vdc
Input ON current: 10 milliamps
Input OFF voltage: Below 4 vdc

5 vdc mode:

Input ON voltage: 2 to 5 vdc
Input ON current: 10 milliamps
Input OFF voltage: Below 0.5 vdc