STRESS ANALYSIS OF THE WELDS IN THE GIRDER

BY

VICTOR GUARINO

Argonne National Laboratory
High Energy Physics Division
Argonne, IL 60439

December 1, 1997

Argonne National Laboratory, with facilities in the states of Illinois and Idaho, is owned by the United States government, and operated by The University of Chicago under the provisions of a contract with the Department of Energy.

---

**DISCLAIMER**

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

---

Reproduced from the best available copy.

Available to DOE and DOE contractors from the Office of Scientific and Technical Information
P.O. Box 62
Oak Ridge, TN 37831
Prices available from (423) 576-8401

Available to the public from the National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161
Introduction:
The girder at the back of each module plays an important structural role in the assembly of the Tilecalorimeter barrel. It is important, therefore, to clearly understand the welds within the girder. In order to understand the stresses in the welds, a 2-dimensional finite element model has been constructed of the girder cross section similar to the model that has been previously used by J. Blocki to analyze the girder. This model is shown in Fig. 1. Plain strain elements were used that had a thickness of 1mm.

Analysis:
In order to verify this model, it was initially run using the same force and boundary conditions as J. Blocki’s model. The forces acting on the girder that have been supplied from J. Blocki’s earlier analysis have been applied to this model, see Fig. 2, and similar results obtained, 200N/mm² max stress in the welds.

Since 200N/mm² is approaching the yield stress of 235 N/mm², it is important to reduce this maximum weld stress. In order to reduce the stresses in the weld, an additional bar was added to the model as shown in Fig. 6 and the FEA model in Fig. 3. Plain stress elements were used to model this additional bar. This bar had a width of 12mm and a thickness that was .04mm. The maximum stress occurred in the welds between the bar and the girder and were 153 N/mm², see Fig. 4. The thickness of the bar was then increased to 1mm and the stress in the weld was reduced to 138 N/mm², see Fig. 5. A bar of this thickness in the girder would be approximately 30mm wide in Z at every submodule.

The use of this bar would be a cheap and simple way to significantly reduce the weld stresses in the girder. The fiber routing scheme and the bolt pattern in the girder need to be examined in order to understand the affect of this bar and to optimize its thickness.

Conclusions:
The current European welding norms do not require stress concentrations within welds to be considered except under fatigue loading conditions. Since this is not the case for our design, the use of the average stress in sizing the welds is allowed under the European welding norms. An analysis of the welds by V. Romanov that only considered the average stress, showed that the average weld stress was 38N/mm², well within acceptable limits. However, it should be kept in mind that the forces on the welds vary significantly along the length of the girder so the average stress may not be an adequate method of analyzing these welds. In addition, since these welds are so critical to the structural integrity of the Tilecalorimeter, it is desirable to examine stress concentrations even though this is not required by the European norms. Therefore, it is recommended that a 30mm wide bar as shown in Fig. 3 be used on the ten modules that see the highest load from the cryostat. This is a very simple and low-cost modification to a small number of girders that will provide significant additional safety.

An additional modification that should be made to the girder concerns the type of welds that are used. According to the European norms, the fillet welds that are shown in the current girder design are not allowed, but recommend penetration butt welds. The design of the girder should be updated to reflect this recommendation.
Figure 1. FEA model similar to that of J. Blocki.
\begin{align*}
P_1 \rightarrow P_8 \text{ in N/mm}
\end{align*}

Figure 2. Forces on girder provided by J. Blocki.
Figure 3. FEA model of proposed design.
Figure 4. Stress plot of proposed design: Rib thickness = .04mm.
Figure 5. Stress plot of proposed design: Rib thickness = .1mm.
PROPOSED GIRDER DESIGN

Figure 6. Schematic of proposed girder design.

DIMENSIONS ARE IN mm.