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Program - Project - Job: **US - LHC DFBX**

Title: **DFBX Shipping Specification**

Introduction

LBNL is currently designing the eight DFBX feedboxes as part of the Large Hadron Collider (LHC). The boxes will be shipped to CERN in Switzerland for installation in the LHC beamline. Each feedbox shall be shipped in its own crate that will provide adequate shock and vibration protection as well as environmental control. This document specifies the design requirements that must be met by the shipping containers based on the geometry of the hardware and the expected acceleration loads for the given mode of transportation.

Shipment Description

Each DFBX feedbox consists of a 1.25" thick stainless steel shell with a cryogenic tank suspended within it along with a series of pipes and high current leads. The eight boxes are comprised of six unique but similar designs as shown in the following LBNL top-level assembly drawings: 24C350, 24C351, 24C352, 24C362, 24C394 and 24C395. Figure 1 shows an image of a 3D model of one of the boxes along with its overall dimensions. Each feedbox weighs a total of approximately 13,000 lb. The location of the center of mass is given in Figure 2.

Destination and Shipping Dates

The feedboxes are to be loaded into the shipping containers at the location of the fabrication vendor after the requirements of the pre-shipment acceptance tests have been met. These requirements are outlined in the Acceptance Criteria Document (LBNL Engineering Note M8XXX). The packages shall be shipped directly from the vendor to the following address at CERN: (TBD). The vendor shall select the appropriate mode of transport for each unit as permitted by the timing of fabrication completion such that the required delivery dates are met as specified in the RFP Statement of Work. The vendor may choose to ship more than one feedbox in the same shipment as long as each is crated separately. Upon arrival at CERN, each DFBX feedbox must again satisfy the acceptance requirements specified in M8XXX.

Shipping Loads and Packaging Performance Requirements

During handling and transport, the shipping crate and enclosed DFBX will be subject to both shock and vibratory accelerations. An analysis has been performed to determine the magnitude of acceleration in

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each coordinate direction that the feedboxes can tolerate. Details of the analyses can be found in LBNL Engineering Note M8043. The following requirements are based on the results of the analyses along with appropriate factors of safety:

- maximum transmitted vertical shock acceleration: $\pm 5.0g$
- maximum transmitted horizontal shock acceleration: $\pm 2.0g$
- suspension system natural frequency range: 5 to 10 Hz

Additionally, the crate shall be designed to undergo a free drop from a height of 6 inches without exceeding the vertical shock limit of 5.0 g's.

The fabricator shall design the DFBX shipping crate to the above specifications and submit for review by LBNL. This review of the design does not imply that LBNL accepts any responsibility for the ability of the crate to meet the design specifications.

Preparation for Shipping

The DFBX feedboxes will require a significant amount of preparation prior to loading into the shipping containers. All DFBX piping shall be back filled with N_2 and capped. Any internal piping that is not fully restrained shall be supported by means of added supports installed through the box end flanges. The added restraints shall be removed after shipping is complete.

The fabricator shall provide air-tight caps for the D1, Q3, JC1 and JC2 flanges. The caps are to include internal features to provide support for the ends of pipes that extend outside of the flanges. The interior of both the vacuum box and the helium vessel shall be filled with N_2 as well. All other external piping shall be restrained as appropriate. The external connections to the current leads are fragile and susceptible to damage. While the leads will not require additional support to withstand the shipping accelerations, protective covers or shields will be necessary to prevent handling damage during loading and unloading of the shipping crate. The feedboxes shall be supported within the crate on the lower surface of the vacuum vessel rather than by the jack support points. The jacks shall be packed separately and shipped along with the feedboxes.

Instrumentation

Four tri-axial recording accelerometers shall be used for shock and vibration monitoring during transport. Two identical units shall be mounted on the DFBX box inside the shipping crate for redundancy. The inside units are to cover a full-scale range of ± 6 g's. A second pair of redundant accelerometer systems shall be located on the exterior of the shipping crates such that they are clearly visible. These units must be protected from being damaged during handling of the crate. The outside units are to cover a full-scale range of ± 10 g's.

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Detailed specifications for the accelerometers will be provided by LBNL. Copies of the accelerometer data records shall be provided to LBNL after each package has been delivered to CERN.

Packaging Features

In addition to providing the shock and vibration isolation as specified earlier in this document, the DFBX packaging shall also incorporate the following features:

- sufficient interior restraint to prevent the feedbox from shifting within the crate
- appropriate and clearly marked exterior features to allow tie down during transport and lifting by means of a crane and/or forklift
- extra interior space and restraints for any miscellaneous DFBX hardware
- provision for repeated access to the feedbox without significant damage occurring to the crate
- protection from prolonged exposure to exterior environments without corrosion or other damage occurring to the DFBX
- clear and obvious exterior labels in both English and French indicating the presence of fragile contents along with shock and vibration recording instruments
- labels warning against tipping the crate from its normal position or stacking any items on top of it
- any welds used in the construction of the shipping crate must conform to AWS code as determined by an AWS certified weld inspector

The shipping crate design is to be reviewed by LBNL prior to fabrication. Each feedbox and shipping crate will be inspected by an LBNL representative prior to being shipped. The fabricator shall be responsible for the ability of the crate to perform according to this specification, regardless of any implied approval by LBNL.

Acceptance Criteria

As previously indicated, each DFBX will be considered successfully delivered to CERN if all of the requirements listed in the Acceptance Criteria Document, represented by LBNL Engineering Note M8XXX, have been satisfied. Furthermore, the shock load limits specified in this document must not have been exceeded as indicated by the accelerometer records. If any of the acceleration limits are exceeded, the DFBX may still be accepted providing that the post-shipping tests do not reveal any damage to the hardware.

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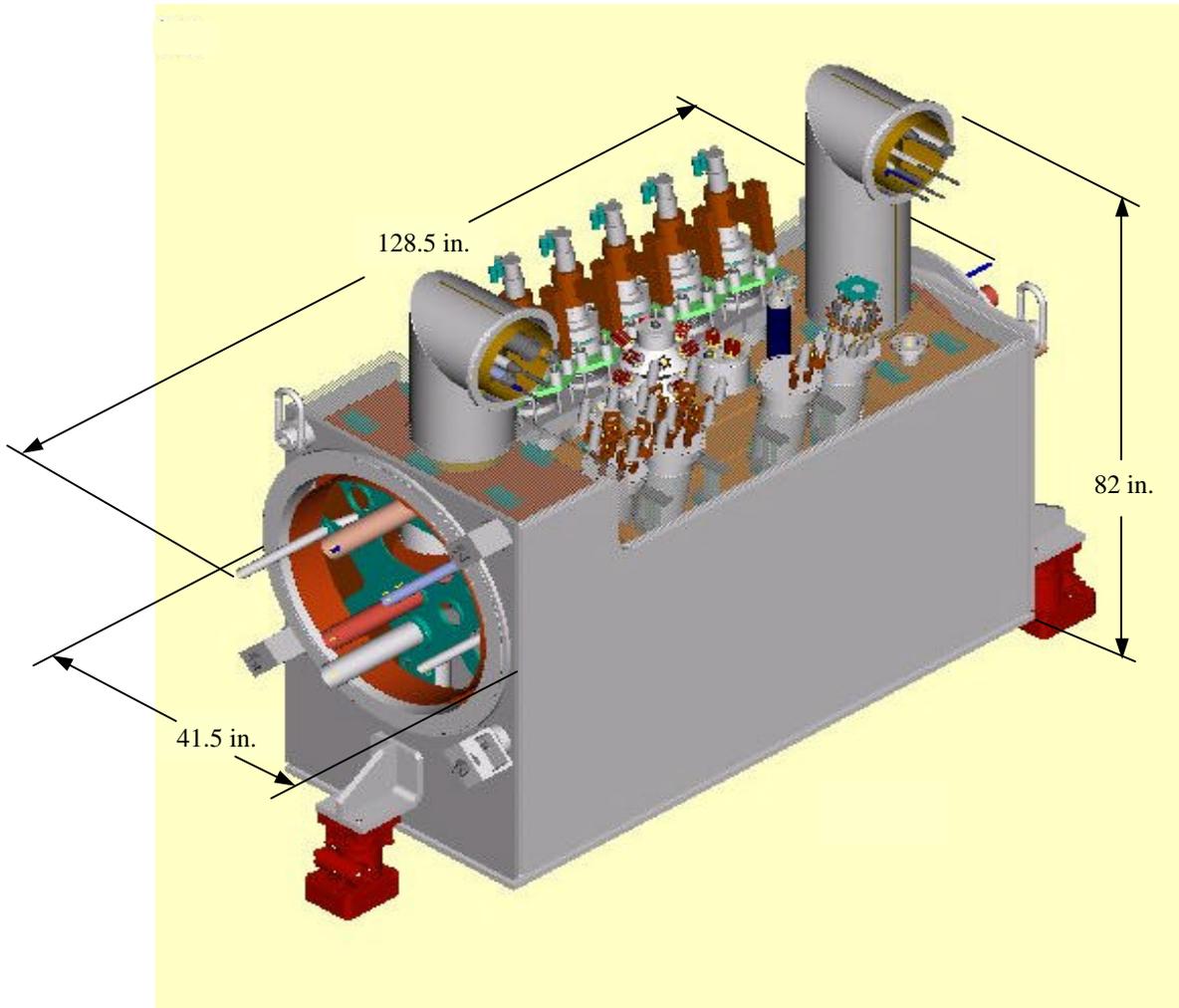


Figure 1. Illustration of the DFBX Assembly Showing Maximum Dimensions (jacks not included)

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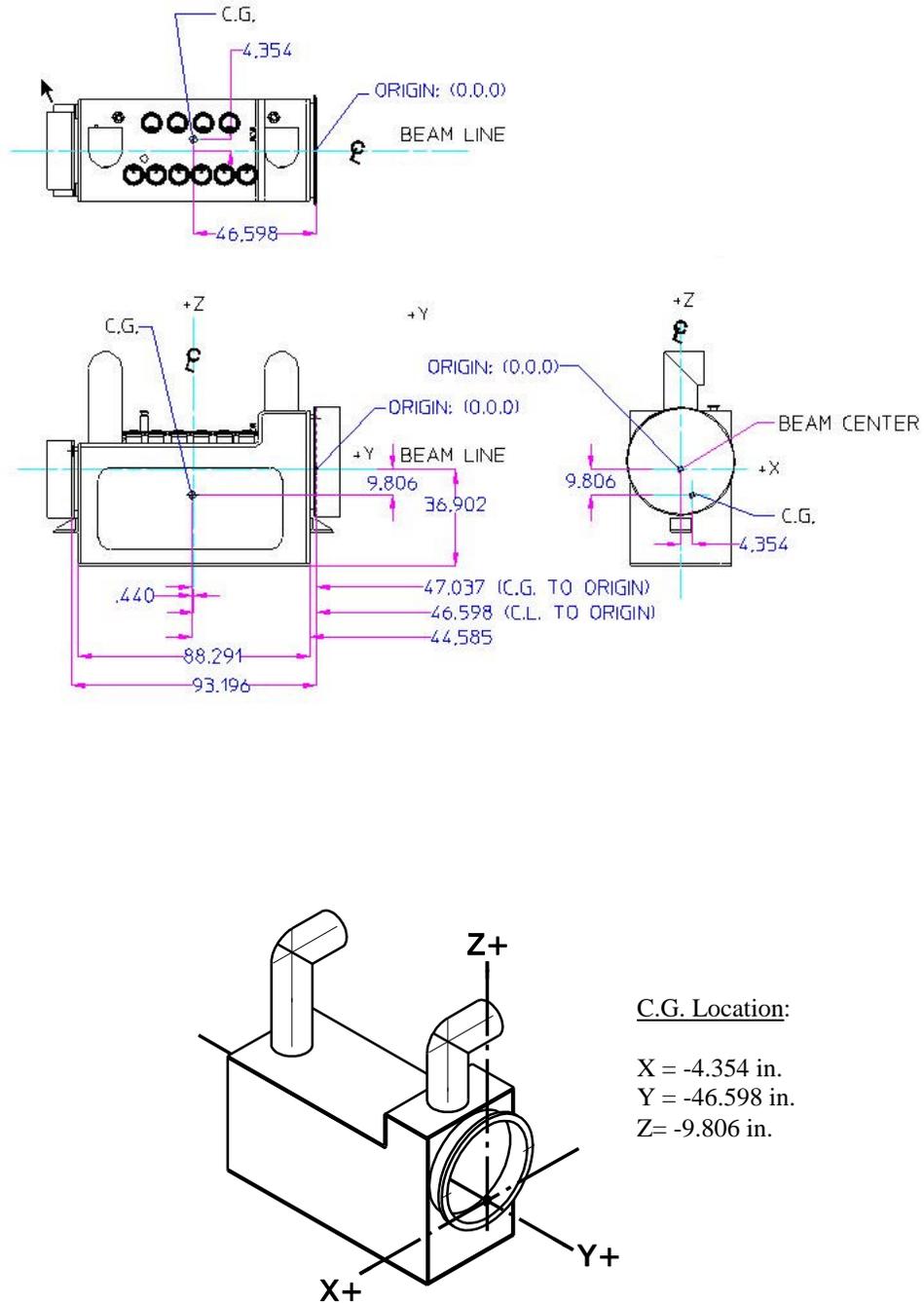


Figure 2. DFBS : Orthogonal Views and Center of Gravity Location