



research
instruments

Cryomodule transport issues

Daniel Trompetter

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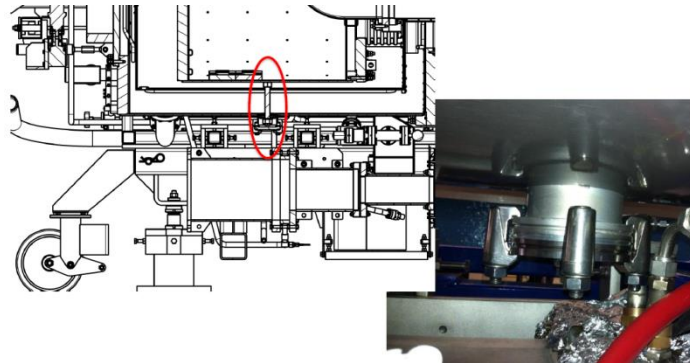
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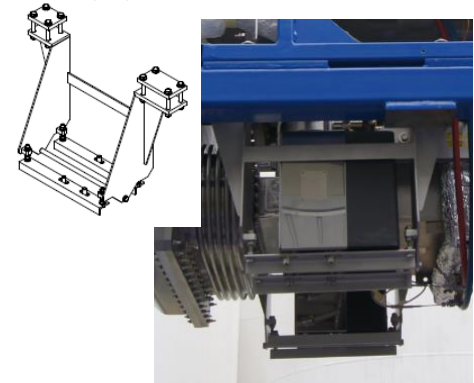
Transportation concept

Design issues

- Think of transportation during design phase!
 - Add ports and connection points for transport protection bolts to fix inner equipment such as the helium vessel / cold mass.
 - Install support structures for heavy external equipment such as ion pumps, etc.
 - If support is not possible, remove external equipment for transportation (might require local clean room work at final destination) and improve welding strength.



500 MHz CESR-B cryomodules
Transport bolt for He-vessel (left)
Ion pump support (right)



Transportation method

Choose for low impact energy

The energy resulting from any kind of shock during transportation is proportional to the product of component acceleration and acceleration time.

Method	Acceleration (rough)	Time of Accel.	Expected impact energy
Sea transportation	Low (<1g)	Long (seconds)	Very high
Land transportation (air suspended truck)	Medium (<10g)	Short (ms)	Medium
Air transportation	Moderate (<3g)	Short (ms)	Small
Warning: Ground handling	High (20g)	Short (ms)	High

Most critical operation is ground handling as equipment has NO suspension!

Transportation surveillance

Trust ?

Define your requirements before contacting your transport agent and when placing the order:

- Allowed transportation method
- Vehicle requirements (suspensions, open top, etc.)
- Handling requirements (e.g. crane only)
- Etc.

Even if everything is defined in your transportation contract:

- Oversea shipment is handled through local agents of your transport agent, communication is difficult or even impossible, requirements are often misunderstood (or ignored?).
- „Standard procedures“ for handling are often „misinterpreted“ (ignored?).
- In transport business time is of the essence, people are not sensitive / dulled by warning signs on almost every parcel.

→ Only trust what you see by yourself! Make sure to monitor what you cannot see!

Transportation surveillance

Trust ? - Examples

Requirement: closed canvas truck, sides and top to be opened (curtainsider / Edscha-trailer).

Requirements was crosschecked and **confirmed** by local agent.



Requirement



Reality



Transportation surveillance

Trust ? - Examples

Requirement: Smooth handling according to airline standard procedures!

Airline standard procedure: Components will always remain on airfreight pallet and on rollerbed system / trolleys until loading to truck



Standard

Night shift ;-)



Furtunately no SRF CM, but SNS CCL components

Result:
Several shock
indicators tripped



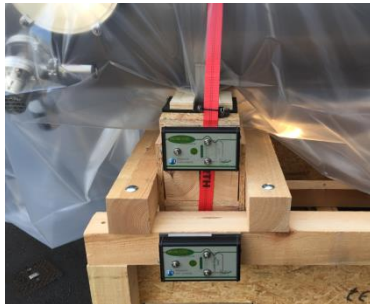
Transportation surveillance

Shock / tilt recorders

Install shock and tilt recorders on your shipment:

- Clearly visible at the outside (sensibilise handling staff)
- Inside (for your control, tripped indicators outside might „accidentally“ be lost)

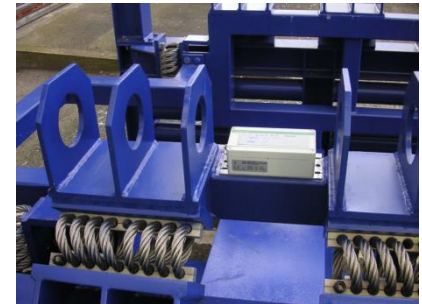
On very sensitive shipments (CMs) install electronic shock recorders for x/y/z acceleration, impact time and shock curves. GPS and GSM depending on carrier. If a shock absorbing package / frames are used, you can verify your absorbers by installing at both, outside (box) and inside (CM).



MESA-CM: pallet / module



CESR-B: Outer frame



CESR-B: inner frame

Transportation surveillance



Personal witness

Experience shows:

- Promises (even by contract) \neq Reality
 - Ground handling: pressure of time / unsensibilised staff.
- On very sensitive shipments (CMs): BE PRESENT!
- At your side / at destination side
 - During any handling step (define in your requirements, responsibility of your local agent)!
 - Get in direct contact with the truck driver / forklift truck driver etc. Even without language knowledge you can point out the warning symbols / shock recorders.
 - Access to airfreight cargo areas might be restricted, try to contact the warehouse manager on duty and ask for special care.
 - If they know that you are present and watching, they are more sensitive.
- **Face to face works better than any document / warning symbol / requirement / contract ...**



Transport packing

Wether / access protection

- (Witnessed) Door-to-door transportation requires less protection against wether and access compared to general cargo.

TARLA cryomodule
Door-to-door (2900 km),
not witnessed



MESA cryomodule
Door-to-door (200 km), witnessed

- CESR-B cryomodules,
Package improvements:
 - For closed truck (left)
 - Access protected (center)
 - Open Trailer (right)



Transportation packing

Shock protection / example ELBE cryomodules

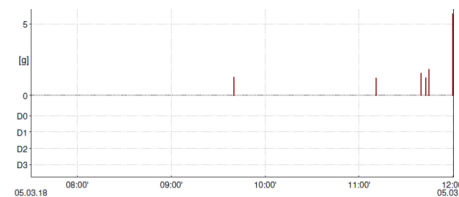
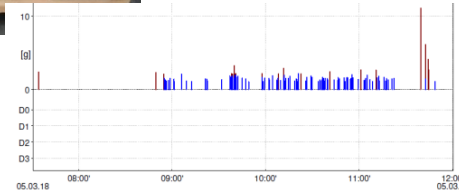
- Sensitive equipment should always have protection against shock impacts!
- Packing and absorbers have to match in size and weight!

ELBE-CM (1400 kg) in CESR-B (4500 kg)
transport frame: NO match!
-> poor shock absorption



ELBE transport frames,
matched for weight.

Shocks at outer frame
(top) are effectively
absorbed at CM (bottom).



ELBE-CM:
Box-in-box



Transportation packing

Shock protection / example CESR-B cryomodules

- A dedicated transport frame for CESR-B CMs (4500 kg) has been designed.
- CM is installed to inner frame, inner frame is resting on coil springs within outer frame.
- Only crane handling allowed (when CM installed), as forklift trucks have no suspension!
- Canvas cover installed for weather / access protection.



Bad luck

Good truck, good brakes, bad straps!

Emergency brake during land transport



CM in transport frame (6500 kg) crashed into control cabinet (energy absorber ;-).



Repair welding onsite was required. CM performance was good!
Cabinet to be rebuilt.

Bad luck

No step!

Packing intended for closed truck transportation (access restricted), but only open truck available.



Handling staff stepped on CM during installation of additional covers, beam vacuum flange was damaged.



→ Complete disassembly, BCP, HPR and reassembly of CM required!

Transport – open issues

For discussion

- Shipment under vacuum vs. vented to N₂ ?