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Supply of casks and canisters for spent fuel dry storage

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ABSTRUCT

Hitachi Zosen has long experience of development, design, analysis, fabrication, test, inspection, and delivery on spent fuel casks more than three decades and also has long experience of fabrication, test, inspection and delivery on spent fuel dry storage canisters for 15 years. Since Hitachi Zosen developed and delivered its first spent fuel transport cask in Japan in 1978, 600 casks and canisters have been delivered to not only Japanese utilities but also US utilities. Over three decades experience, innovations and technologies have been introduced to fabrication process to supply casks and canisters for spent fuel transportation and dry storage.
Hitachi Zosen will continue to supply casks and canisters to support spent fuel transportation and dry storage. For future prospect beyond the spent fuel transportation and dry storage, Hitachi Zosen is considering to supply geological disposal canisters to dispose of spent fuels and high level waste with accumulated fabrication experience and technologies over three decades.

1. INTRODUCTION

Hitachi Zosen, since the first spent fuel transport cask developed and delivered in Japan in 1978, has lot of experience of development, design, analysis, fabrication, test, inspection and fabrication, test, inspection and delivery on spent fuel transportation and dry storage casks more than three decades. Hitachi Zosen also has long experience of fabrication, test, inspection and delivery of spent fuel dry storage canisters for 15 years in United States. According to those long histories and successful results on cask and canister supply, Hitachi Zosen has delivered 600 casks and canisters to not only Japanese utilities but also US customers and utilities.

These remarkable records were made by challenging innovation and new technologies Hitachi Zosen has had for long years.

This report shows examples on our fabrication innovative experiences and introduction of new technologies.

2. History and Experience of Hitachi Zosen

Hitachi Zosen is now the one of spent fuel cask and canister supplier in Japan. Following subparagraphs show Hitachi Zosen's history and experience on cask and canister briefly.

2.1 Hitachi Zosen Corporation

Hitachi Zosen, Osaka based Japanese company, established in 1881 by English man, Edward Hazzlet Hunter, as a ship building company and now is a heavy industrial company. Hitachi Zosen used to be a one of the largest ship building company in the world and there was an opportunity to develop nuclear powered ship in 1950's in Japan. After that, Hitachi Zosen entered into nuclear powered ship, later, cask and canister field.

2.2 Cask History in Hitachi Zosen

Hitachi Zosen started research and development on nuclear powered ship from 1956. Along with the R&D, we worked on developing the small cask for spent fuel of nuclear powered ship from 1962. After those development work, Hitachi Zosen acquired basic technology of developing cask design from National Lead Industry and we developed the Japanese first spent fuel transportation cask called HZ-75T in 1973. The design of this cask was finally licensed by Japanese Government in 1976.

After two years fabrication, Hitachi Zosen delivered this HZ-75T cask (Fig. 2.1) in 1978. This is also the first completed spent fuel cask in Japan.

As described above, Hitachi Zosen got the technologies and experience to develop, design, analysis, fabricate, test, inspect and deliver the spent fuel transport cask.

Fig. 2.1 HZ-75T Spent Fuel Transport Cask

After success of development and delivery of HZ-75T cask, Hitachi Zosen next developed NH-25 cask (Fig. 2.2) used for transportation of post irradiated nuclear fuel to Nuclear Fuel Development lab in Japan and this cask was delivered in 1979.

Fig. 2.2 NH-25 Transportation Cask

In 1980's, Hitachi Zosen challenged fabrication of overseas casks. Japanese utilities contracted with BNFL and COGEMA to reprocess their spent fuel at the plant in England and France and a certain quantities of casks were necessary to transport spent fuel from Japanese nuclear power stations to those reprocessing plants. Hitachi Zosen built 7 of TN-12/2 casks (Fig. 2.3) and 14 of Excellox casks (Fig. 2.4).

Fig. 2.3 TN-12/2 Transport Cask

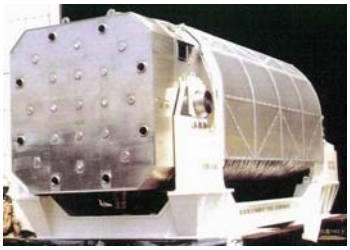

Fig. 2.4 Excellox Transport Cask

With starting construction of commercial based spent fuel reprocessing plant in Japan, transportation casks were necessary to forward reprocessing plant spent fuel. Nuclear Fuel Transport (NFT) and some cask suppliers including Hitachi Zosen developed transportation casks called NFT casks. Hitachi Zosen developed two types of cask, NFT-10P cask and NFT-22B cask at the develop and design stages.
At the fabrication stage of NFT casks, Hitachi Zosen built 14 of NFT-14P casks (Fig. 2.5) and 3 of NFT-10P casks (Fig. 2.6).

Fig. 2.5 NFT-14P Transport Cask

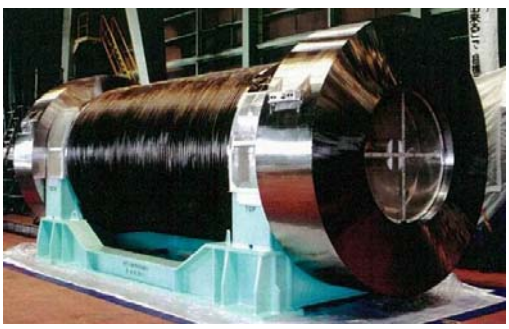

Fig. 2.6 NFT-10P Transport Cask

On the other, Hitachi Zosen developed spent fuel dry storage cask (Fig. 2.7) in 1997 and delivered total 15 casks from 2001 through 2004. Those casks have stored 61 BWR spent fuels each at the site spent fuel storage facility.

Fig. 2.7 Spent Fule Dry Storage Cask

In late 1990's Hitachi Zosen has started entering US spent fuel dry storage field and we have been a subcontractor of NAC International and Transnuclear, Inc. to fabricate and supply casks and canisters to support US spent fuel dry storage. As of today, Hitachi Zosen has delivered total 536 casks and canisters to US customers and utilities in 15 years. At the same time we have reached total 600 casks and canisters deliveries to Japanese and US customers as shown in Table 2.1.

We believe these records show Hitachi Zosen has been proven as the recognized good cask and canister fabricator in Japan and United States.
Those records also have been realized by our quality assurance system which has worked well, fabrication experience, innovation and technologies.
Those fabrication innovation and technologies are introduced in following paragraphs.

3. Innovation and Technology

Hitachi Zosen has accumulated much experience of fabrication on casks and canisters for long time. Those remarkable fabrication records cannot be realized without progress on fabrication. And fabrication is not making progress in itself with only experience. Innovation and technologies are the important key to make progress on fabrication. The following is our innovation and technologies introduced to fabrication of casks and canisters.

3.1 Dry Storage Cask Basket Fabrication

Hitachi Zosen developed and completed the design of our first spent fuel dry storage cask in 1997. We acknowledged that the cask could be fabricated with existing technologies we had ever used on cask fabrication at that time, however, it was quite new design on the basket and the problem was happened on its fabrication mockup.

3.1.2 Dry Storage Cask Basket Mockup

The basket design required the longitudinal weld between the aluminum blocks located around the channels as shown in Fig. 3.1.1.

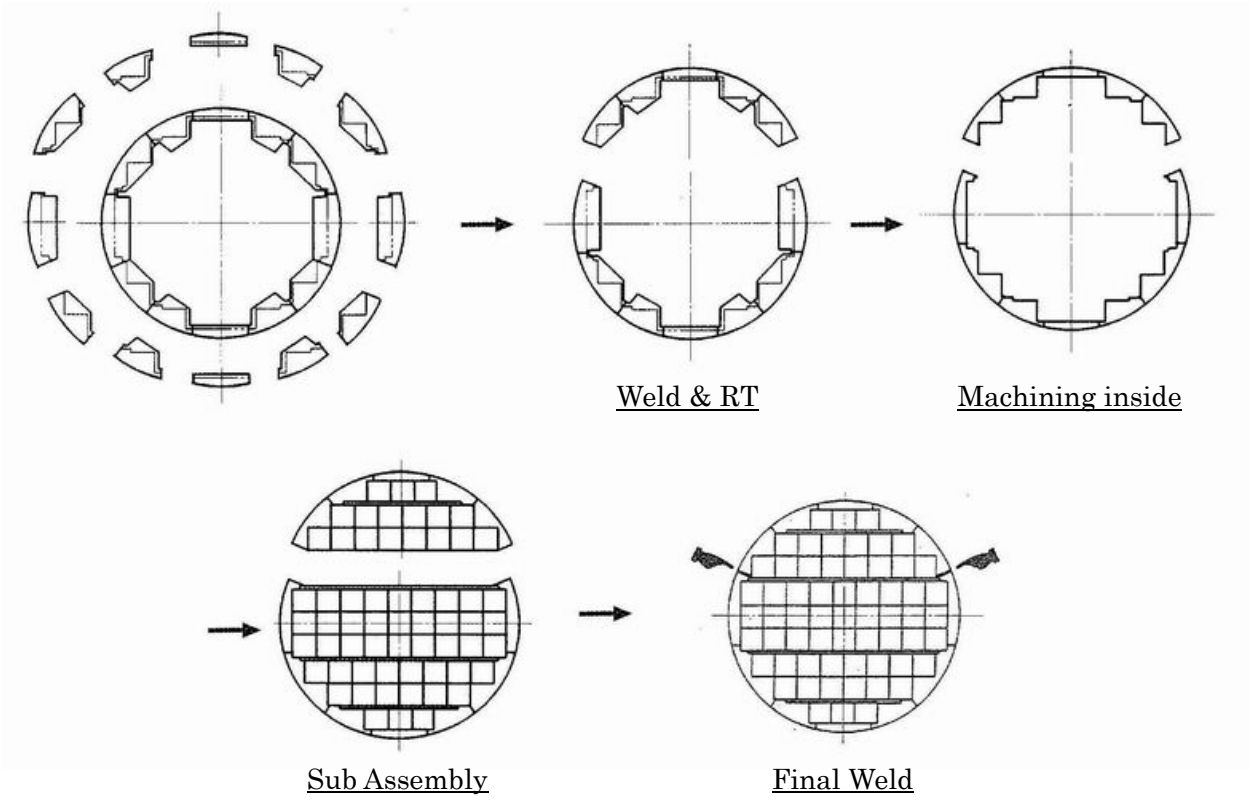

Fig. 3.1.1 Dry Storage Cask Basket Fabrication Plan

Since the final welds at two locations must be welded after whole assembly of the basket, weld distortion might be happened and might cause a problem on channels of the basket, therefore, mockup test (Fig. 3.1.2) was planned and implemented to confirm fabrication feasibility.

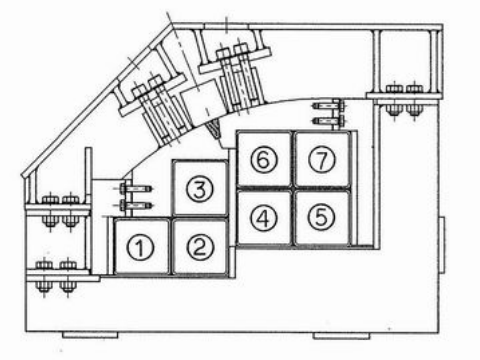

Fig. 3.1.2 Dry Storage Basket Fabrication Mockup

3.1.3 Dry Storage Basket Mockup Result

As we had foreseen, weld distortion was happened and the distortion made square tube deformed. This caused dummy fuel gauge did not go through at some of the channels (Fig. 3.1.3).

Fig. 3.1.3 Dry Storage Basket Fabrication Mockup Result

3.1.4 Innovation on Dry Storage Cask Basket

The basket fabrication mockup got the weld distortion problem out and we knew conventional aluminum weld was difficult to control preventing weld defects. Therefore, Hitachi Zosen made a decision to change the basket fabrication process with different view point.

After consideration of this problem, we gave up to use the longitudinal peripheral block on basket and changed to use aluminum forged heavy wall (170mm, 6.7 inches) rings and applied Electron Beam Welding (EBW) system Hitachi Zosen had for joining the aluminum rings to shell (Fig. 3.1.4 through Fig. 3.1.6).

Then the aluminum shell inside was planned to machine for making inside shape to install channel parts.

Fig. 3.1.4 Electoron Beam Welding System

Fig. 3.1.5 Aluminum Forged Rings to Shell

Fig. 3.1.6 Machining Prior to Channel Parts Installation

However, this challenge faced the difficulty of EBW on 170mm (6.7 inches) thick aluminum heavy wall joint, however, we, finally, successfully developed the weld and applied EBW on basket fabrication (Fig. 3.1.7 and Fig. 3.1.8).

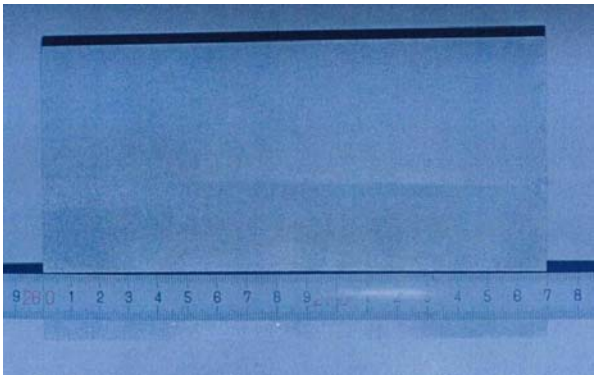

Fig. 3.1.7 EBW on 170mm (6.7 inches) thick Al

Fig. 3.1.8 Dry Storage Cask Basket

3.2 NAC Multi Purpose Canister (MPC) Fabrication

Hitachi Zosen's first canister project was Multi Purpose Canister system projects working with NAC International.

Most difficult part of fabrication was making basket square tubes used for channels spent fuel installed in. The square tube wall thickness was 1.214 mm (0.048 inches) and the cover called cladding installed to four outside of square tube to protect and retain borated aluminum sheet under the cradding was only 0.455 mm (0.018 inches) thick and these thin sheets had to be welded (Fig. 3.2.1).

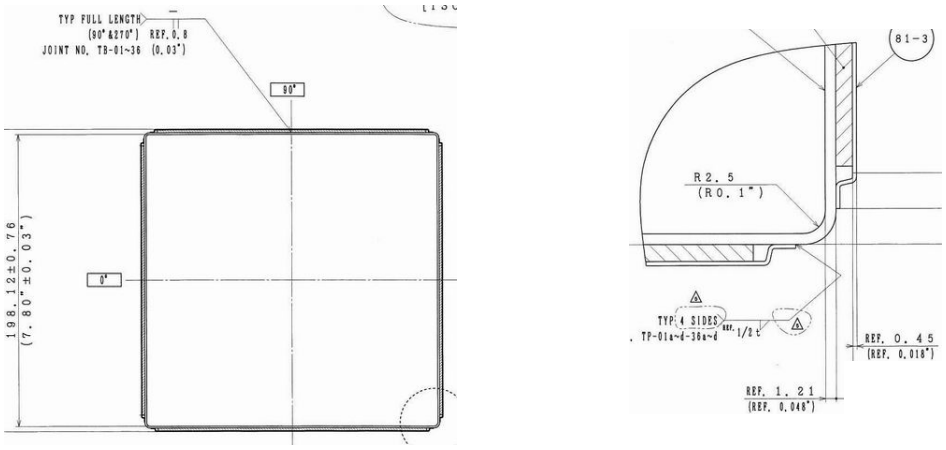

Fig. 3.2.1 NAC MPC Tube Weld

It was the challenge and difficult to use conventional weld we had used for construction of heavy wall casks, but very precise weld was required. Also the square tube must be very straight with extremely precise tolerance.

3.2.1 Innovation on MPC Square Tube

From the situations of the fabrication difficulties, Hitachi Zosen made a decision to introduce Laser Beam Welding (LBW) system to build this new canister. 2kW YAG Laser Beam Welding system was installed and we worked with our lab welding team to develop LBW procedure to implement the production.

By the development of the LBW, weld parameter was successfully obtained and the weld was good with no distortion (Fig. 3.2.2).

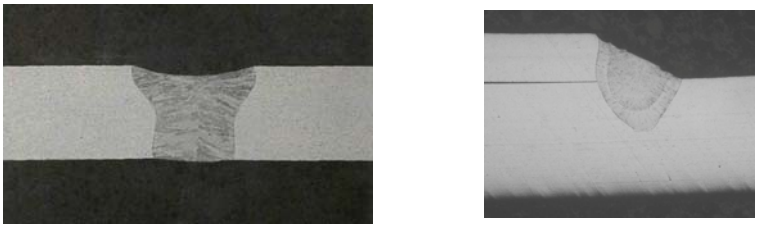

Fig. 3.2.2 LBWs on MPC Square Tube and Cradding

We Introduced LBW system with no doubt to accomplish the canister and this decision led success of all four NAC projects, two MPC projects, two Universal Multi-purpose canister System (UMS) projects. This new technology and introduction of the device to the fabrication have changed our production and extended to other products region.
As the result of introduction of the LBW system, we have successfully made NAC PWR MAGNASTOR projects.

3.3 TN NUHOMS 24PHBL DSC Fabrication

Similar application of LBW is for fabrication of TN NUHOMS 24PHBL canister basket guide sleeves. Guide sleeve is a channel of the basket, shaped with square tube and its thickness was 2.67 mm (0.105 inches) (Fig. 3.3.1). Guide sleeve fabrication was one of the important key to build NUHOMS 24PHBL

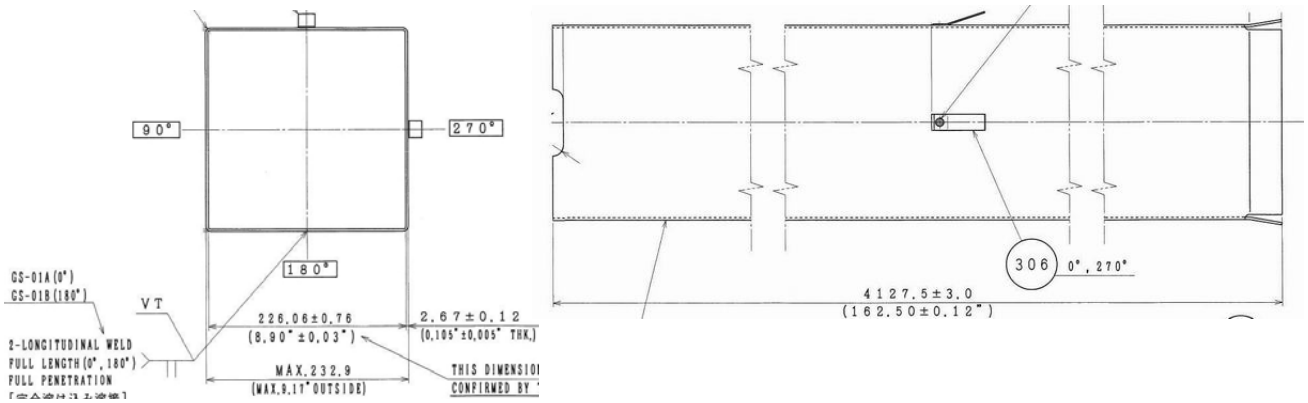

Fig. 3.3.1 NUHOMS 24PHBL Guide Sleeve

3.3.1 TN NUHOMS 24PHBL DSC Guide Sleeve Fabrication

As the sheet thickness used for guide sleeve is thin, it was difficult to make it with conventional weld without distortion, such as GTAW or GMAW process, because the guide sleeve had to be straight with very tight tolerance, therefore, we applied LBW on this guide sleeve fabrication also as we applied LBW to MPC tubings.
After trying out the tests, our team with lab group got the best weld parameters, correct shape and good weld appearance were obtained and NUHOMS 24PHBL canister fabrication was successfully done (Fig. 3.3.2 and Fig. 3.3.3).

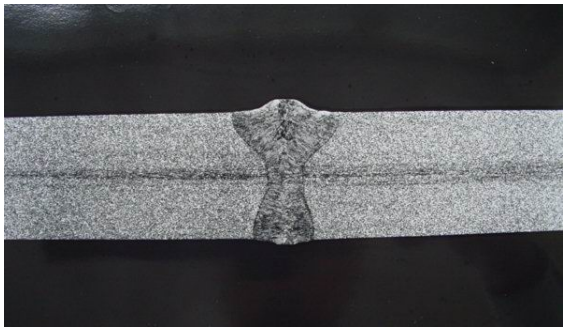

Fig. 3.3.2 LBW on NUHOMS 24PHBL Guide Sleeve

Fig. 3.3.2 NUHOMS 24PHBL DSC

We again acknowledged that LBW distributed fabrication quality higher, and much less weld distortion, less welding time.

4. Supply Cask & Canister for Future Needs

As the situation is known at each country who has nuclear power station, the casks and canisters used for dry storage are necessary to keep full core reservation at spent fuel pools for each reactor as long as nuclear power generating is going on and implement decommissioning at the nuclear power station where the shut down is proceeded. In both cases, casks and canisters are used for removing spent fuels from the pool and storing them at the ISFSI until the final depository facility starts operating. As described in above, Hitachi Zosen has accumulated the experience and technologies on fabricating casks and canisters, Hitachi Zosen continues to supply the casks and canisters from now on and keep trying to challenge new innovations and technology we have not ever done to solve fabrication difficulties.

Furthermore, geological disposal canister projects and development are going on at several countries, Hitachi Zosen thinks our experience of development, design, analysis and fabrication technology is effective to support those disposal canister projects and we are very looking forward to work on disposal canister projects and supply those canisters all over the world.

5. Conclusion

As the summary, this report concludes as follows.

Hitachi Zosen;

(1) has many experience of development, design, analysis, fabrication, test, inspection and delivery of casks for more than three decades since 1978 and supported Japanese spent fuel transportation and dry storage.

(2) has used the cask experience in Japan for fabrication and supply spent fuel dry storage canisters in United States.

(3) has resolved many fabrication difficulties by innovation and introduction of new technologies.
(4) continue to supply casks and canisters to support spent fuel transportation and dry storage.
(5) has a plan to move on supplying geological disposal canisters to solve future spent fuel, high level waste storage and disposal problem.

6. Acknowledgements

Hitachi Zosen could continue cask and canister supply until today and we could supply many casks and canisters by the support of all people from customers, suppliers, our seniors and internal folks, who concerned on all projects we have ever done.
I would like to continue supplying casks and canisters to support spent fuel solutions.