A Borated-Alumimum Cask Design for Used Fuel Cooling

Part 2 - Regulatory compliance

A Center for Advanced Energy Studies Collaboration
University of Idaho-Idaho Falls
Boise State University
with
Sakae Casting USA, LLC

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Try not to repeat the same material

Quick review though

Allow me to introduce the team again

Prof. Bob Borrelli, University of Idaho-Idaho Falls (CAES) - ME!

Prof. Richard N. Christensen, University of Idaho-Idaho Falls (CAES)
Nuclear Engineering Program Director

Prof. Brian Jaques - Boise State Univeristy
Samuel Pedersen - Boise State University - Graduate Student

Mr. Takashi Suzuki - CEO - Sakae Casting

Mr. Mark Delligatti, President - Table Rock, LLC
30 years experience in licensing casks at NRC

And additional work from Dr. Brenden Heidrich - NSUF R&D Infrastructure Lead

The story so far

We received an Idaho Global Entrepreneurial Mission award

Design of borated-Al used fuel cooling cask

We have several challenges

Thermal cooling - determining heat transfer coeffients in the cooling tubes and cask materials - Rich

Materials optimization - Boron chemical form, solid solution with aluminum, homogeneity - Brian

Shielding - How thick will the cask be? How much boron do we need? - ME!

Licensing - What are the right regulations? What is needed for licensing? - ME!

Market penetration - Who wants it? - Sakae

I discussed shielding design previously

Results for dose rate showed that there are considerable design challenges

Try backfill materials

Put the cask in something else

Get help

We had argued some pools are filling up

As partial justification for designing this cask

(I talked about ROK because I knew it best from my Berkelely-KAERI postdoc)

Let's look at this now - USA, Europe, Asia

We know the policy in the United States

Once through fuel cycle, no active repository, no interim storage

Fuel stored onsite in pools and some dry storage

75% pool capacity filled in 2011 and 63% pool capacity filled in 2017

About 55000 MTHM stored in the pools and 2200 MTHM discharged/year

USA is using dry cask storage at many sites

Lots of plants are extending the operating licenses, more fuel discharged

Argued either way - storage might be an issue long term or might be able to construct dry casks to keep up

France?

Not really

France has a closed fuel cycle

Reprocess 850 MTHM per year

EDF announced a plan to build 8000 MTHM centralized pool at Belleville-sur-Loire

~120 miles south of France

UK not really either

Operate advanced gas cooled reactors mostly

Sellafield reprocesses the AGR fuel

There is a single PWR at the Sizewell B site

Dry cask construction started in 2016, and fuel was loaded in 2017

They also call the pools 'ponds' so if you're doing a search for used fuel data in the UK and use 'pools', you're going to waste about half a day figuring out they call them 'ponds'

Germany and Belgium are phasing out nuclear

Germany has 7 operating reactors, down from 19

Germany exported used fuel to France for reprocessing

Currently have 16 dry storage facilities including a centralized one at Gorleben

Belgium also has 7 operating reactors

Used fuel was reprocessed prior to 1999 ban

Remaining MOX fuel will be burned till it runs out

4 pools reracked

Some dry storage at Doel

Europe does not look like a credible market

There might be a case for Belgium

I couldn't find data on pool capacity

They are reracking, but since 2 plants shut down, but Doel 1 and 2 pools are empty

They built a new pool in repsonse to the reprocessing ban

It's not known how full that is either

I didn't look at Finland and Sweden because they already have repository sites

ROK has 23 total reactors, 19 PWRs

6541 MTHM used fuel with 70% of space full in the pools at 4 sites

Could be filled by 2021

Public opposition to interim facilities becoming permanent

Fabricated higher burnup fuel, reracked pools

Fuel transferred from older sites where storage is running out, to newer sites

Don't want to reprocess due to cost

And they would need to find somewhere to store subsequent reprocessing waste

Taiwan has 6 reactors on 3 sites - 2 operating

3400 MTHM used fuel all in pools

Pool capacity at **97%**

Taiwanese legislature refused to approve restart at Kuosheng due to the lack onsite used fuel storage

Citizens concerned about a Fukushima-type pool accident because Taiwan is in similar region

Other political opposition to shipping fuel for reprocessing

Atomic Energy Council just issued construction license for dry cask storage at Kuosheng

Japan and Fukushima is well known here

Loss of water in the pools led to partially melted fuel

Dry casks were in tact though

13000 MTHM used fuel with 55% capacity filled (2013) - could be higher now

Used to ship fuel overseas for reprocessing - ended in 2005

Rokkasho scheduled to open in 2021 (for now)

2900 MHTM stored at Rokkasho out of 3000 MTHM capacity

Dry casks in use at Fukushima and Tokai Daini

Local government approval required

Asia is a potential market for the Sakae cask

Small countries

Centralized storage is problematic

Lack of onsite storage space

Difficulties with local approval

Limited development of dry cask storage

Sakae cask could alleviate space and extend time for dry cask construction

So what?

Sakae has a path to pursue a market plan now

Visiting TaiPower this summer to talk about the cask

Attending an exposition in the UK in October

I suggested that NRC certification will offer a higher level of credibility

More attractive product

I wanted to start developing compliance guidelines now

If we can build a prototype, we use the guidelines as part of the testing program

10CFR72

Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-level Radioactive Waste, and Reactor-Related Greater Than Class C Waste

Dry storage has been in use in USA since 1986

Vendor obtains Certificate of Compliance under 10CFR72

Currently 4 companies have obtained compliance each with different models

NUHOMS, MAGNASTOR, HI-STAR, HI-STORM (51 total)

Operator also obtains a license to use the casks at the site

Defined as Independent Spent Fuel Storage Installations (ISFSI)

Acronyms are why people hate us

Sakae cask is intended to be single use - storage at reactor site

Pools operate under power reactor license stipulated in 10CFR50

Dry storage cask inventory assessment (2016)

FCRD-NFST-2014-000602, Revision 2

Robert H. Jones, Jr.

10CFR72 has a lots of subparts and paragraphs

It's a bit of a challenge to communicate

What I did was just go through the regulation, identify relevant parts

Explain how we would have to demonstrate compliance

I was hoping there would be specific performance measure

I made a #fancy table, but it's impossible to reproduce here

I'm just going to hit the relevant parts of the regulation

We don't start until Subpart F

General design criteria

Part	Description	Action item
72.120b.1	GTCC can't be stored with the used fuel	Sakae cask is only for used fuel
72.124a	Criticality safety	Demonstrate subcritical configuration with MCNP modeling
72.128a.1	Test, monitor safety components	Wait till prototype design
72.128a.2	Shielding	My current task
72.188a.4	Heat removal	Current research

Subpart G addresses quality assurance

I'm admittedly not so strong in this area

Part	Description	Action item
72.140b	QA program	Sakae QA on June 8
72.144c	QA requirements	Need Sakae review
72.146a	Quality standard design	Need Sakae review
72.154a	Purchased material	When boron loading is determined
72.158	Special processes	May be relevant to boron loading

The problem here is we need to know how the boron-Al mix can be done first

Then modify Sakae QA program

It's also not clear if this applies to compuational tools

Subpart L lists requirements for approval

Part	Description	Action item
72.230a	Application	Safety analysis report
72.236a	Specify fuel type	PWR
72.236b	Design basis for safety	Safety analysis report
72.236c	Criticality safety	Current research
72.236d	Radiation shielding	Current research
72.236e	Redundant sealing	Prototype phase
72.236f	Passive cooling	Not currently
72.236g	Cask lifecycle	Current research
72.236h	Loading/unloading compatiblity	Prototype phase

What's next?

This turned out to be really interesting

Subpart F seems like we have covered mostly as part of research process

Working on QA with Sakae and Boise State on Subpart G

Also will look for other cask company QA programs

Getting help from Mark on Subpart L with other safety analysis reports

He licensed one of the Holtec designs

Already working on passively cooled design with Rich

Other materials from Brenden like NUGREGs and RGs

Find students I can actually pay to help me