CORIUM “CONE” EX-BUILDING FUEL LOCATION INVESTIGATION PROPOSAL INFORMATION
SimplyInfo.Org Research Team – Submission To IRID

OVERVIEW

https://e-reports-ext.llnl.gov/pdf/503271.pdf
The link above is a study performed by Lawrence Livermore Laboratory titled;
“Possible Methods to Estimate Core Location in a Beyond-Design-Basis Accident at a GE BWR with a Mark I Containment Structure“

Many of the methods similar to our recommendations are identified in the LNL article concerning temperatures, radiation levels and neutron generation population.

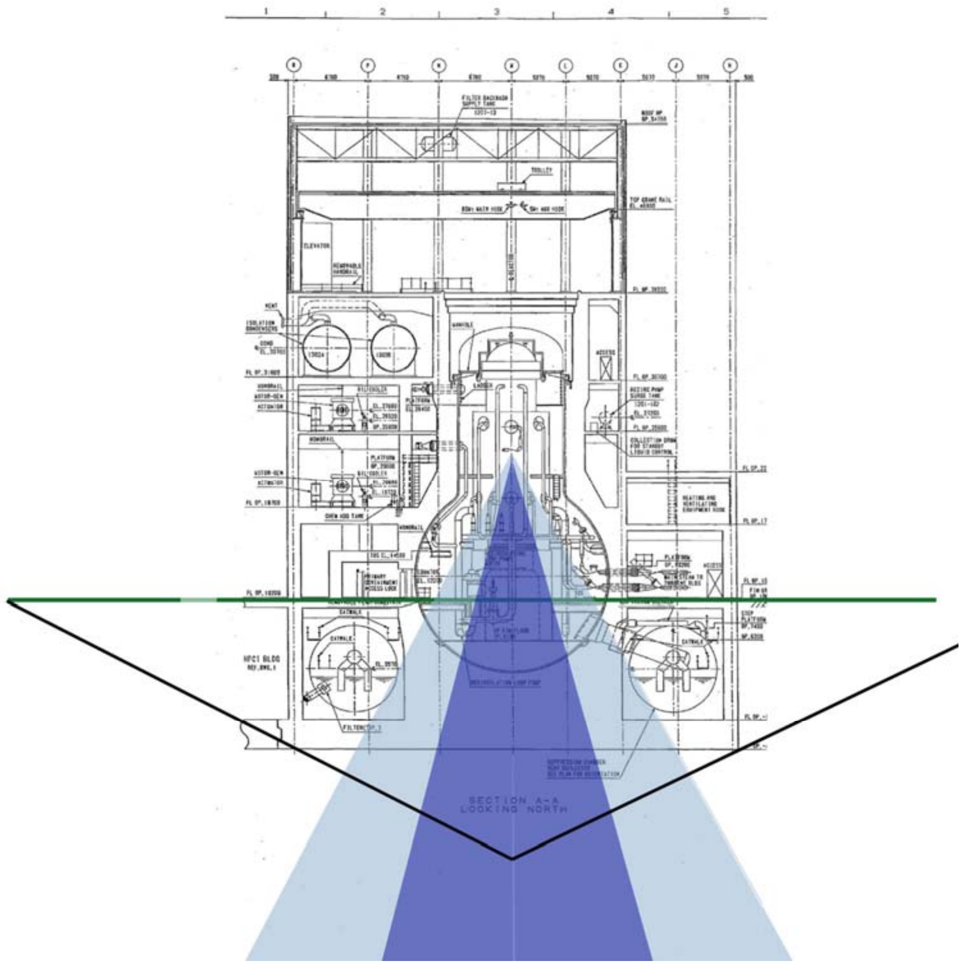
FUKUSHIMA UNIT 1-3 MELTED FUEL (CORIUM) STATUS AND LOCATION

There have been minimal efforts by TEPCO to quantify and qualify the melted fuel at Fukushima Reactor Units 1-3. Multiple investigations into these buildings have revealed massive damage, extreme radiation levels and evidence of potential corium and corium paths. TEPCO cannot tell us what the status is of the melted fuel from a subcritical condition, no nuclear instrumentation has been employed to determine the neutron population and there are no definitive reports or studies that show more than general overlay images.

We have studied this issue and have the following recommendations which will assist those involved to identify the status of the corium including neutron generation, radiation, temperature and off gas generation. Our recommendations will also create the supporting data to understand and map potential and direct locations of corium that may have left containment (PCV) or the reactor building. In addition, once the ex-building corium identification phase is completed, a similar approach can be utilized for in vessel/building fuel debris removal.

EX-BUILDING CORIUM LOCATION

The first phase of this process includes the investigation outside of the reactor buildings and focuses on an area bounded by a cone shaped region. This emanates from the center of each core to an approximate 30-60 degree cone area down from the core height and extending out of the building through the ground. The boundaries of this cone will be used to envelope the potential area where fuel corium could be located.

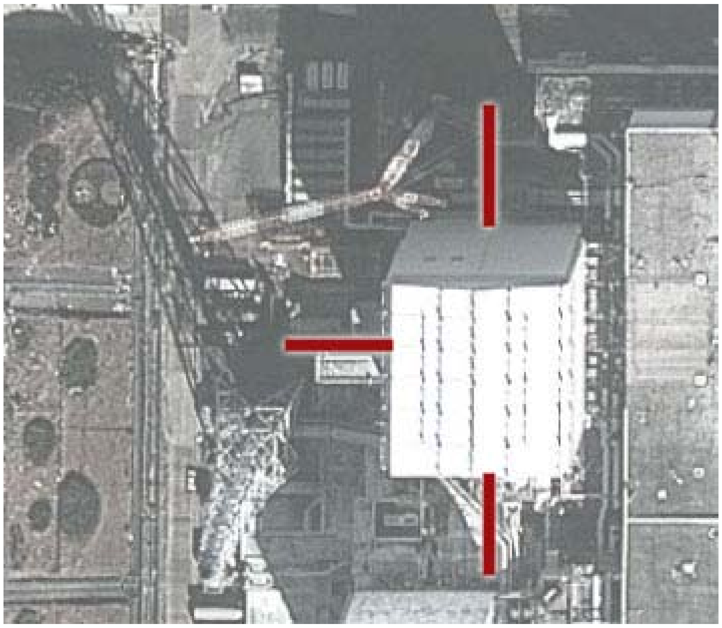


(green = ground grade, black = drilling angles)

In order to compensate for any groundwater that may be encountered within the drilled holes, all instrumentation will be enclosed in a sealed instrument container which will allow insertion into a wet environment. Tubing for sampling of air activity will be inserted separate from the sealed instrument container and lowered to a level just above the water level. As the drilling is progressing each drilling location data set will be used to compare other locations and added to development of the 3D images.

The process involves:

1. Locating the precise core drilling positions on 3 sides of each reactor building to allow drilling 3 holes at different angles underneath the building into the intercept of the corium cone line.



2. Extending the drill hole and inserting the probe measurement equipment beyond the corium cone intercept boundary as needed to obtain data from the instrument probe package.

3. Install a video camera with the instrumentation probe package, with backup, to videotape the monitoring process.

4. Complete a 3D map of each cone area utilizing the instrument probe insertion to the various holes. Upon completion and generation of the 3D corium location mapping, keep the data packages in the drilled holes to create a real time monitoring system for corium activity.

5. Measure the following in 1 meter increments with a sealed probe package inserted in the drilled holes:

- Neutron population using a fission chamber, signal conditioning and a LogN recorder
- Temperature profile
- Radiation profile
- Humidity profile
- Pressure profile
- Air activity profile

SUPPLIES AND EQUIPMENT SUGGESTIONS

Fission Chambers

Fission chambers similar to these sold by Centronic are suggested.
http://www.centronic.co.uk/sitemap.htm

From Centronic's website:

"*Fission chambers provide a very large pulse from a neutron induced reaction and can be used in either pulse or direct current mode. When used in pulse mode non-neutron pulses can be discriminated against fairly easily, even at low neutron fluxes. This makes them ideal for use in high mixed fields, such as encountered near a nuclear reactor as part of In-core or Ex-core nuclear instrumentation. Small fission chambers, such as the Centronic FC4A, are designed for flux scanning in narrow tubes in the region of fuel elements. DC fission chambers have a longer lifetime than boron ion chambers; due to the fission coating not burning up as quickly as the boron coating. However, fission product activity limits the dynamic range of DC fission chambers, typically to the top 2 decades of reactor power"*

Geiger Müller Tubes
GM tubes similar to those sold by Centronic could be used for this purpose.
http://www.centronic.co.uk/downloads/Geiger_Tube_theory.pdf

From Centronic's website:
"*With increasing awareness of the environment and of protection levels, the detection and measurement of nuclear radiation becomes increasingly important. The Geiger Müller tube, with its high detection sensitivity, robust construction and simple circuitry, continues to be one of the most widely used radiation detectors in all areas of application."*

Radiation Tolerant Products

http://www.centronic.us/radiation_detectors.htm

From Centronic's website:

Features:

- *Non contact product.*
- *Option of flush and non flush mounting models.*
- *Radiation tolerant to 100 kGy or 1 MGy depending on model.*
- *Can be supplied with screened and unscreened cables up to a length of 300m.*
- *Intrinsically safe model available.*

Temperature, pressure, radiation & humidity equipment:

These parameter instruments can be standard off the shelf instruments with probes packaged to fit in the core drill hole size and can be equipped with recording and analyzing instrumentation.

Air Activity:

We recommend that air activity be measured with a sniffer tube that will be directly attached to an air activity monitor with detector, recorder and alarm capability. A recommended range of detectors for application at each drill site are manufactured by Canberra with the following units suggested:

http://www.canberra.com/products/env_rad_monitoring/integrated-systems.asp?Accordion1=1

CAM110FF Series Continuous Air Monitors

From Canberra's website:

The CAM110FF Series offers two options for beta/gamma particulate and iodine in air monitoring:

- *the CAM110IFF for 131I monitoring, or*
- *the CAM110PIFF for beta/gamma particulate and iodine monitoring.*

The system monitors radioactive airborne levels in either working spaces, or via a process tubing connection to a remote stack, duct or other air space. Visual indication and contact outputs for remote alarms are provided for high radiation and failure conditions. Analog outputs are provided to the plant monitoring system. The CAM110 Series CAMs can be set for isokinetic monitoring if desired.

Another suggested model is the Portable Gas Monitor PGM102

From Canberra's website:

The PGM102 is a self-contained mobile monitoring/sample collection station for radioactive noble gases, particulates, iodines and tritium in a gaseous sample media. The inlet gas sample passes first through a dual charcoal cartridge and a 0.3 micron filter paper which removes iodines and particulates from the sample. It then passes through an unshielded 8.3 L counting chamber with a dual phosphor scintillation detector (plastic scintillator and BGO crystal). The BGO crystal provides a gamma activity signal with a slower rise time pulse, thus allowing it to be identified by the preamplifier and used as a compensating signal for the gamma background.

Workers in protective clothing can readily move the handcart station to a selected site, connect the electrical and pneumatic systems, and activate the monitoring station functions in a fraction of the time required to set up separate monitoring and sampling systems.

The PGM102 is designed for use at locations where ac electrical power and a source of pressure or vacuum is present for transport of the sample through the monitoring system. An external vacuum pumping system may be connected to the air outlet connection if the inlet sample flow is not pressurized.

CORE DRILLING

Core drilling capability will be needed to bore angled holes from the locations around the reactor buildings on 3 sides. The equipment will need to be able to drill holes at discrete angles from the surface and under the building to the intersect of the cone angles. Drilling is anticipated to pass through general construction backfill as well as clay and mudstone at the bottom of the core drilled holes.

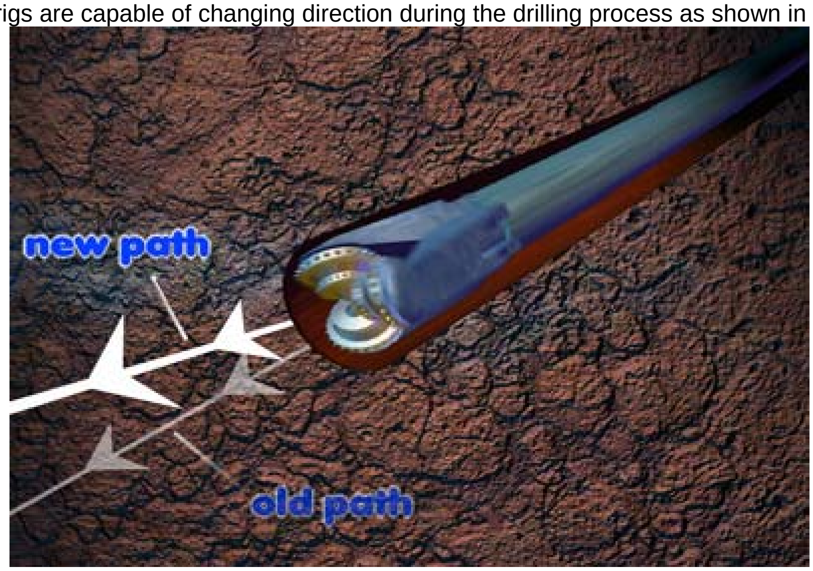
One caveat is that the equipment used for the drilling process will probably not be able to be removed from the site to be used elsewhere after being used at Fukushima Daiichi due to contamination issues. This cost should be reflected in any cost analysis.

Two such drilling rigs are presented for consideration:

The first example is the directional drilling rig made by the Sino core drill company
http://www.sinocoredrill.com/photo/sinocoredrill/editor/20130625111910_32111.jpg

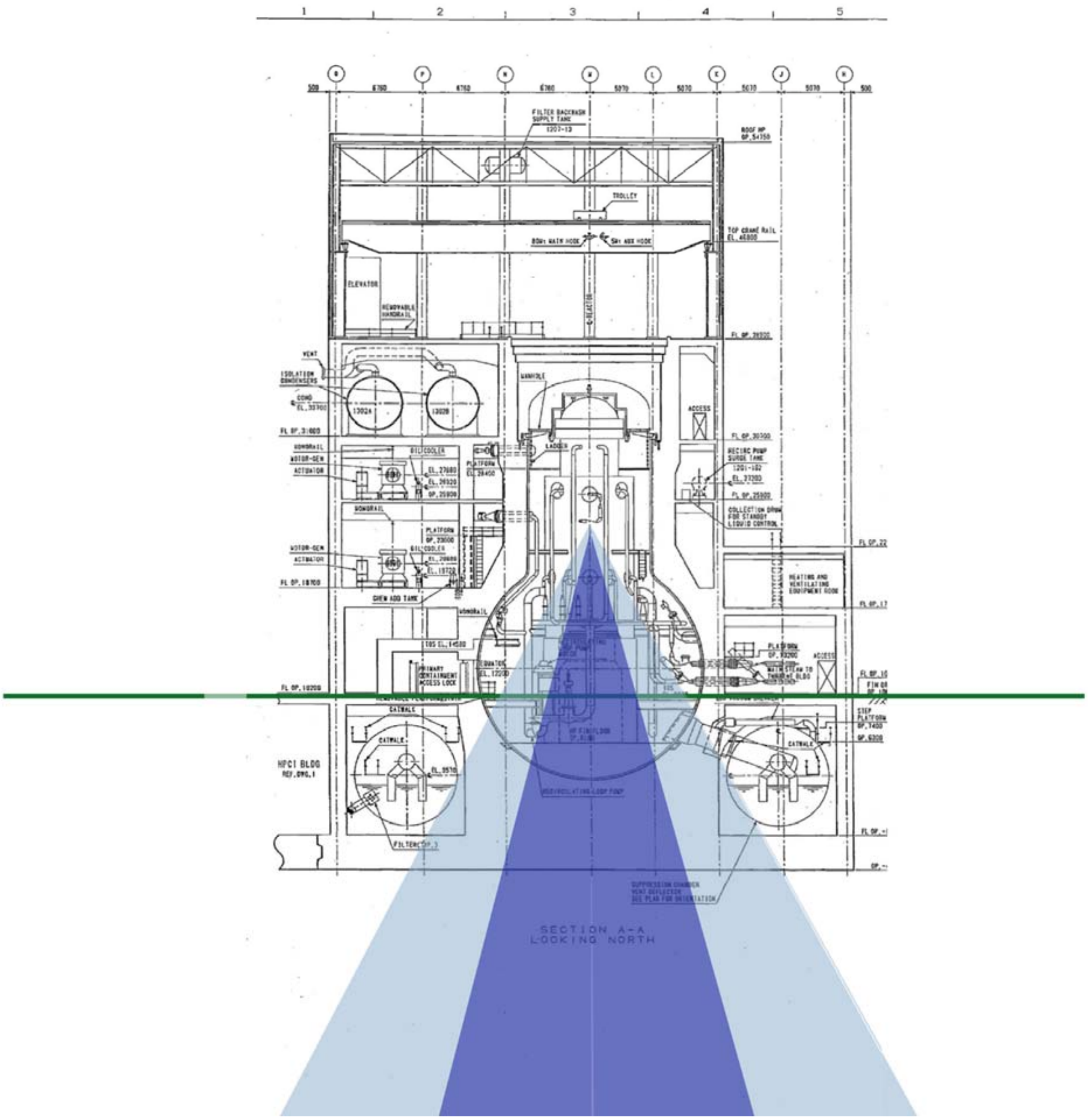
This drilling rig adds a benefit with distance from the operating cab to the actual drill head.

These drilling rigs are capable of changing direction during the drilling process as shown in the next image



The second example is a smaller drilling rig made by the Strega Company:
http://www.strega.co.th/images/rigs_tools/D50.jpg

DIAGRAMS AND REFERENCES



Dark blue = 30 degree cone
Light blue = 60 degree cone

Background information on "low flat angle drilling" called HDD - Horizontal Directional Drilling, or Directional Boring
http://construction.about.com/od/Special-Construction/a/Horizontal-Directional-Drilling.htm

Standard well drilling costs for comparison
http://wiki.answers.com/Q/What_is_the_average_cost_to_drill_a_well?#slide=2