Spent Fuel Pool Level Instrumentation: Through-Air Radar VEGAPULS 66

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How It Works: Through-Air Radar

- A packet of microwave pulses are transmitted by the antenna system.
- This pulse is reflected by the water and received by the same antenna system.
- The running time of the RADAR pulse from emission to reception is proportional to the distance to the water surface.
- “Distance to water” surface is translated into the level information.

A Simple and Proven Principle.
Through-Air Radar System Architecture

10” Horn Antenna
All Stainless Steel.
No electronics here, a simple funnel.

Waveguide Pipe
63ft. with 1.5” ID
74ft. with 2” ID
Stainless Steel.

Sensor electronics
Fist size, stainless steel housing.

Display Panel
Battery back-up, 120VAC/24VDC power converter.

Remote Display,
e.g. Main Control Room

Thermobox allows installation of sensor electronics in 212 degree saturated steam environments.
No radiation shield.

Signal wire.
4…20mA: No limitation
HART: 164ft., more poss.

Primary Power

Signal wire.
4…20mA
No limitation

Without a doubt: Flexibility to fit every pool.
SFP Product Demonstration in Lynchburg, VA 9/19/2012

The debris, steam and moving water capability of the AREVA/VEGA Through-Air Radar system were demonstrated in front of customers.

**Written customer summary:**

“In conclusion, the demonstrations offered compelling evidence that the Through-Air Radar measurement technology is a viable candidate.”

Installation including a long waveguide with 180° and 90° bends is raised and lowered above pool.

The attendees can see the display at all times.

The 27ft ‘Moving Wall’ allows the simulation of quickly rising and falling water level. Large debris is introduced in the beam area at different heights - with no effect.
VEGAPULS 66 Successfully Passed IEEE344-2004 Testing

Testing (external provider) on Nov. 30, 2012

Testing was also performed per EPRI TR 107330, with a peak requirement of 14g.
Through-Air Radar Installation at Hanford Waste Treatment Plant

Over 300,000 VEGA Through-Air Radar Devices in the field.
Several hundred supplied to Hanford Waste Treatment Plant
Through-Air Radar Installation in a Typical PWR
VEGA Americas offers different Through-Air Radar versions.

Chosen C-Band Radar is ideal for extreme process conditions

- References in various industries and on US NAVY ships.

VEGAPULS 66 is specifically made for “Level measurement of liquids with strongly agitated media”.

- Bubbling or sloshing water don’t affect the measurement.

Non-contact measurement.

→ Unaffected by water temperature, density and movement.

Condensation is ignored.

Most Suitable and Reliable Technology.
VEGAPULS 66 is designed for level measurement in liquids with strongly agitated media.

Saturated steam conditions are no issue for the measurement, as demonstrated by AREVA.

Radar looked at a boiling/agitated water surface.

Steam has no effect on the level reading.
High density smoke was simulated in the same chamber.

- First independently.
- Then simultaneously with saturated steam.

Dense smoke has no effect on the level reading.
Through-Air Radar

VEGAPULS 66 is Fully Tested

Not affected by extreme seismic stress

Not affected by Shock, Vibration

Not affected by interference, not interfering with function of other electrical/ electronic devices.

No interference with function of communication devices.

Software developed and tested to toughest international standards. Independent FMEDA available.

Certified for use in most sensitive environments.

IEEE 344-2004
Recommended Practice for Seismic Qualification (Diablo Canyon +10%) of Class 1E Equipment for Nuclear Power Generating Stations
Tested to 14g

EPRI TR 107330

US Navy and Military Specs

ASTM F-2044-0
Military Standard for Tank Level Indicators

MIL-L-23886C(SH)
Military Standard for Tank Level Indicators (Shipboard)

MIL-S-901D
Shock Tests, High Impact, Shipboard Machinery, Equipment and Systems, Requirements for

Mili-Std-167
Mechanical Vibrations of Shipboard Equipment

Mili-Std-461/462
DOD Interface Standards - Requirements for (and Test Methods for) the Control of EMI/RFI Characteristics of Subsystems and Equipment

Federal Communications Commission (FCC)

FCC Part 15
Radio Frequency Devices - Low Power Intentional Radiators

Safety Integrity Level (SIL)

IEC 61508
Functional safety of electrical/electronic/programmable electronic safety-related systems (incl. Failure Modes, Effects and Diagnostics Analysis) [System reaches SIL 3 in double channel diverse redundant architecture]

IEC 61511-1
Functional safety - safety instrumented systems for the process industry sector - Part 1: Framework, definitions, system, hardware and software requirements

Hazardous Location Safety

Class 3600 1998 Approval Std for E1. Equipment for Use in Hazardous (Classified) Locations

Class 3610 1999 Intrinsically Safe Apparatus

Class 3611 1999 Approval Standard for Non-Incendive E1. Equipment

Class 3615 1989 Approval Standard for Explosion Proof Applications
Objects floating on the water will not impact the correct reading.

Objects submerged below the water will not be seen.

If the water level drops to uncover submerged debris (or built-in structures), the return signal will normally be greater for the water level and the actual water level will be detected.

Concrete debris will not affect the reading as concrete isn’t a good reflector.

Physical separation of the second device prevents concurrent loss of both readings.

Except in extreme cases, debris is not an issue.
SFP Level Measurement Through-Air Radar

- Tracking of 29” x 29” target 27 feet away through hallway

*Unaffected by the undefined environment with lots of metal structures.*
Partial Obstruction Ignored by VEGA Through-Air Radar

- Target (simulated water surface)
- Sample Obstruction/Debris
- Horn Antenna

If the system detects multiple targets, it will always follow the largest one, ignoring other obstacles.
Advantage of Through-Air Radar Surface Tracking Capability

► Through-air radar will continue to track water level and **ignore fallen objects in beam.**

► Guided-wave radar cannot track level below point where conductive object (no matter how small !) contacts probe.

**Can ignore debris while providing accurate spent fuel pool level measurement.**
In-situ calibration

Horn antenna is rotated to calibration position simply by loosening the lap joint flange screws.

Flange away from pool minimizes risk of dropping parts in pool.

A hand-held target can be walked along the poolside at known distances to check sensor calibration.

Simpler to Calibrate.
Challenges of Guided Wave Radar

- Higher complexity design (coax cable, connector, wire guide, stilling tube are additional, compared to Through-Air Radar).
- Objects touching the wire guide above water affect the measurement → Stilling tube required.
  - Costly mounting (some in-pool) and seismic qualification challenges (force of moving water hard to define, regulatory uncertainty)
- Highly sensitive coax-to-stainless connector.
- Mineral insulated coax cable in conduit complicates installation.
- In-situ calibration is difficult.
- 24-27ft. more exposed length (wire guide).
- Higher cost (more components, rad-proof components, stilling well, costly installation).

Guided Wave Radar is Available to AREVA through VEGA but not Selected due to the Above Issues.
AREVA Value Proposition

- **Simple and reliable:** Off-the-shelf, few & simple parts, nothing in the pool and only stainless steel in the SFP room. Easily installed/operated, no maintenance.

- **Environmental endurance:** Demonstrated to operate in adverse conditions (i.e., steam, smoke, boiling/agitated water surface). The solution is not affected by strong forces of moving water and can see past large debris.

- **Right for nuclear:** Seismically tested in accordance with IEEE 344-2004. Tested per MIL for shock, vibration, EMI/RFI. SIL3 software.

- **Proven applications:** 300,000 industrial, military, nuclear navy and NPP references, including Hanford Waste Treatment Plant and Savannah River.

- **Lowest Lifecycle Cost:** Fewest parts, easy qualification, no maintenance.

- **Great regulatory Certainty:** “Nothing beats a stainless steel pipe.” No analysis for radiation proof components needed, no need to evaluate forces of moving water and nothing to mount in the pool. Proven in nuclear environment.

Through-Air Radar – Safe, Simple, Reliable and Economical.
“Pulse Burst Radar accurately and reliably measures a wide range of media in a broad range of process conditions, from calm product surfaces and water-based media to turbulent surfaces and aggressive hydrocarbon media. As a non-contact device, Pulse Burst Radar is not susceptible to the complications that arise whenever a probe contacts the process media, such as coating by viscous media or corrosive attack due to aggressive chemicals. The greater the measuring range, the more does radar prove itself to be the economical solution, given the cost of extended probe lengths. Radar is virtually unaffected by temperatures, pressures, the presence of vapors, or air movement within a vessel's free space. Changes in specific gravity, conductivity and dielectric constants also have no effect on measurement accuracy. As a 100% electronic instrument, the absence of moving parts translates into low maintenance costs. As a two-wire, loop-powered device, power requirements and installation are vastly simplified.”

(Source: Other US Vendor)
AREVA SFP Website

- List of Certificates (Quality Assurance section)
- Product Documentation (Operation and Maintenance Manuals, Spec. Sheet for Display, Safety Manual, Brochures)
- Demonstration Video (Video Tab)

Information for your Informed Decision, frequently updated.
SFP Level Instrumentation
Complete Solution by AREVA

- **Mod. Package**
  - Plant specific detail design. Ideally provided as part of EPC contract.
  - Benefit: EC package by AREVA supports correct input for product manufacturing and provides a single point of accountability.

- **Hardware Delivery**
  - Simple and off-the-shelf solution with maximum regulatory certainty.
  - Augmented quality with all testing completed. Documentation available.
  - Benefit: All requirements fulfilled. No in-pool mounting. Simple.

- **Implementation**
  - Training. Site installation and commissioning by AREVA DZ LLC or customer resources with AREVA field engineer.
  - Benefit: Complete, seamless solution by AREVA, clear responsibilities.

Maximized Certainty, Lowest Installed Cost.
Through-Air Radar Moveable Liner Test

- Moveable wall section to simulate rising and falling water level
  - L-Shaped section allows test of corner and side wall mounting
  - Horn antenna mounted close to wall
  - Range tested 0 to ~27 feet
  - Fallen object obstruction test

Verified under actual conditions.