Significance and Use of ANSI Standards for Portable Detectors

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I Introduction

Portable or hand-held radiological detection instruments are universally used to assess unknown levels of direct radiation and radioactive contamination ranging from natural background to levels associated with emergency response.

The user of a portable detector may not recognize that factors that are provided by the instrument manufacturer or calibration facility for converting an instruments response to a radiation source may be insufficient to satisfy the accuracy requirements for the situation

These accuracy requirements are to reduce the consequence risk from an inaccurate evaluation and false conclusions.

High level measurement risks:

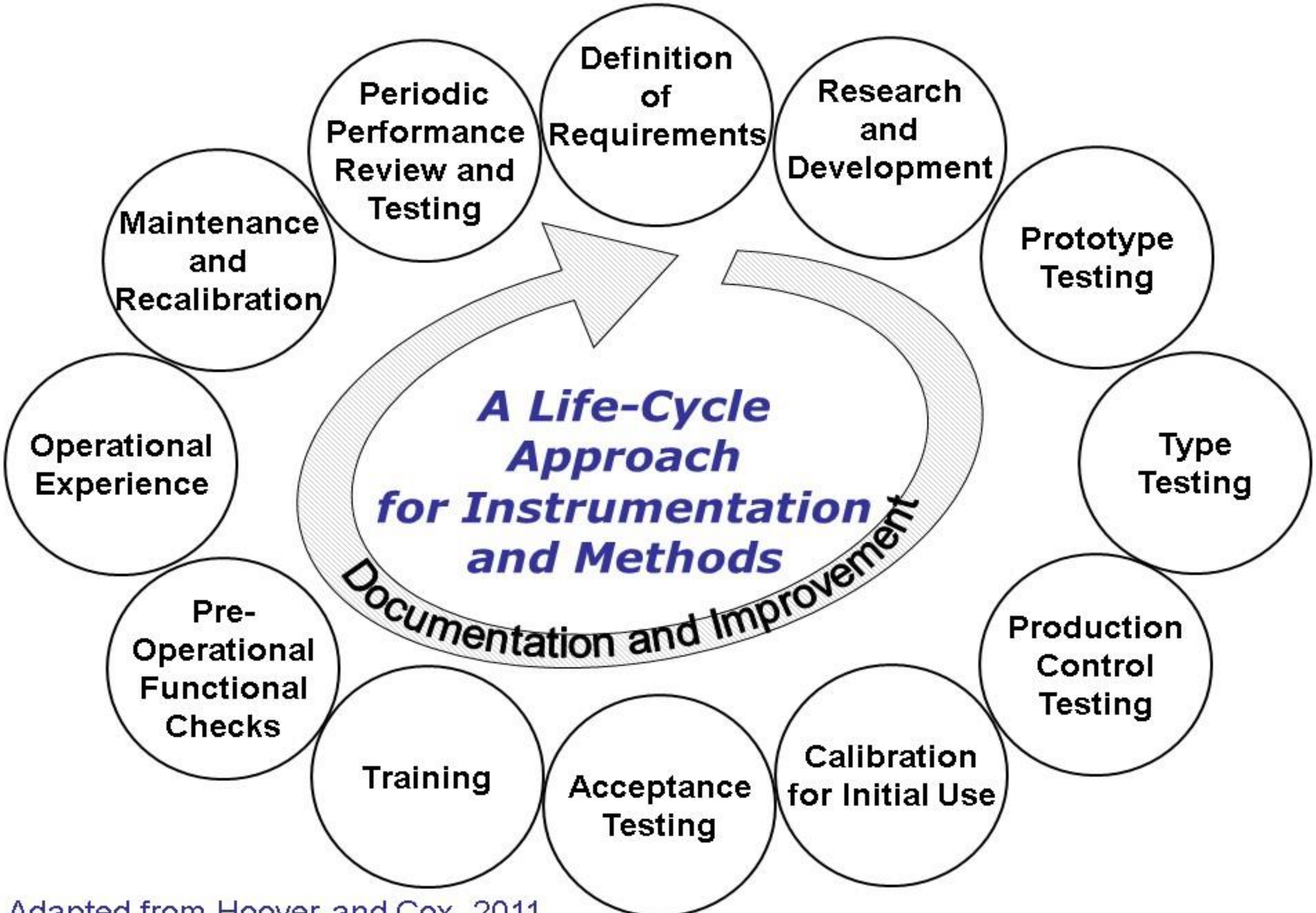
- Under estimate (false negative) – potential harm and/or additional exposure to the individual from inadequate protective measures.
- Over estimate (false positive) – over protection of the individual resulting in reduced task efficiencywith added exposure and/or excessive clothing/equipment producing negative health effects (heat stress, etc.).

Low level measurement risk:

- Conservative estimate (false positive) – excess and un-necessary decontamination resulting in additional time, resources, waste generation or investigating a non-existing source, and the increased cost associated with each.
- Non-conservative estimate (false negative) – possible release of radiation/contamination above acceptable levels. In addition to added costs, if discovered, there are potential regulatory and public relations “fallout”.

II Instrument Life Cycle

- Figure 1 illustrates the life-cycle for portable radiation detection instruments from initial development and testing and initial calibration prior to use, through operational use, maintenance and re-calibration, to final disposition with feedback and needs definitions by the user



Adapted from Hoover and Cox, 2011

This life cycle can be separated by three phases based on the primary users of standards.

- Development and test – primary user: manufacturer,research labs
- Calibration – primary user: calibration facilities
- Operations – primary user: radiation assessers

The secondary users for all three phases are the radiation assesssors and regulators

The significant operations communities for portable instrument use are:

- Facility decommissioning and environmental restoration measuring low level activity (near background)
- Radiological controls (Radcon) involving intermediate levels (mR/h – R/h)
- Emergency response (1 R/h- 1000 R/h)

Two phases of the life cycle that are covered by existing ANSI N42 standards are development and test (ANSI N42.17AC), and calibration (ANSI N323AB).

There are standards that provide guidance for portable instrument users performing measurements near background.

- ANSI N42.33 Portable Exposure Rate Meters (PERMs) for Homeland Security.
- ASTM 1893-13 Selection and Use of Portable Radiological Survey Instruments for Performing In Situ Radiological Assessments to Support Unrestricted Release from Further Regulatory Controls

There are currently no ANSI standards for selection and use for intermediate and high levels of radiation and radioactive material

The initial development and testing phase requirements are described in ANSI N42.17AC-2022 combining qualification test protocols for both normal and extreme environments). The primary users of this standard are the instrument manufacturers. This standard includes calibration.

The calibration requirements for portable instruments are provided in ANSI N232AB-2013. The primary users of this standard are the calibration facilities.

These requirements include initial calibration, normally the responsibility of the manufacturer, and re-calibration

ANSI N42.33 – The scope of this standard is measurement of X- and gamma-ray activity for dose rates less than 10 mR/h or 0.1mSv/h

The portable instruments addressed by this standard are used for detection and interdiction of uncontrolled radiation and radioactive sources.

ASTM 1893-13 – The scope of this standard is measurement of radioactivity near background levels for supporting unrestricted release of surfaces.

Other guidance for low-level measurements are provided in documents such as MARSSIM. There is no comparable standards for High level measurements

- The remainder of the presentation will describe important features of ANSI N42.17AC-2022 and
- ANSI N323AB-2013

III ANSI N42.17AC-2022

- This standard establishes the minimum performance requirements for portable radiation and radioactive material measurement instruments.
- Individual tests are defined for anticipated operating conditions, including radiological, environmental, and eletro-mechanical conditions.
- The tests are defined for ranges of both normal operating and extreme operating conditions.
- This process begins with feedback from the user communities defining their needs. On the life-cycle diagram this is the “definition of requirements” element,

ANSI N42.17AC

- The standard includes a “Standard test conditions” table that is applied to the majority of the ANSI testing standards. The table is to define both the testing laboratory environmental conditions and the instrument testing conditions.
- This is Table 1 and it is applied in this standard to the lab operating environment only.
- The standard includes an additional table that defines “normal” and “extreme” environmental performance test conditions. This is Table 2.

- **Table 1 Standard Test Conditions**

Influence quantities	Acceptable range for standard test conditions
Warm-up time	< 5 min, or as stated by the manufacturer
Relative humidity	Ambient ± 10% up to maximum of 75%
Ambient temperature	20°C to 24°C
Atmospheric pressure	70 kPa to 101.3 kPa
Line voltage*	Nominal voltage ± 5%
Frequency*	60 Hz ± 0.5 Hz
Angle of incidence of radiation	Direction stated ± 5°
Background radiation	≤ 25 μR/hr
Nonionizing electromagnetic field of external origin	Less than the lowest value that causes interference
Magnetic induction of external origin	Less than twice the induction due to the Earth’s magnetic field
Controls	Set up for normal operation
Contamination by radionuclides	Negligible
Reference point	As stated by the manufacturer

•**Table 2 Normal and Extreme Environmental Performance Requirements**

Parameters	Normal	Extreme
Operation temperature	-10°C to 50°C	-20°C to 60°C (Category 1) -40°C to 70°C (Category 2)
Storage temperature	-10°C to 50°C	-60°C to 70°C
Relative humidity (%RH)	14% to 100%	3% to 95%
Shock (peak acceleration)	50g	100g
Vibration	2g	3.5g
Ambient pressure	70 to 101.3 kPa	55 to 108 kPa
Average daily temperature variation (used for instrument durability)	17°C	37°C
Radiation resistance	None	10,000 rad
Drop	None	1 meter onto concrete floor
Rain	None	0.25 inch per hour
Fog	None	6-hour exposure
Battery	8 hours at respective temperature extremes of operation temperature	8 hours at respective temperature extremes of operation temperature

ANSI N41.17AC

This standard specifies the performance requirements and test protocols in the following sections

1. General test procedures based on Tables 1 and 2.
2. General physical characteristics to be tested, such as readout units, battery checks, alarms, controls, etc.
3. Battery lifetime requirements for normal and extreme environments.
4. Radiation response to be consistent with calibration requirements.

Note: Performance requirements 2 and 4 carry over to the user.

ANSI N42.17AC

5. Electronic response for both normal and extreme conditions, including response times stability interferences from RF, magnetic, ionizing radiations, for example.

6. Environmental conditions such as temperature range, temperature shock, humidity, mechanical shock, vibrations for both normal and extreme conditions.

7. Additionally extreme condition tests include condensing atmospheres, drop tests, moisture (rain and fog) in addition to the above.

ANSI N42.17AC

Each performance section includes:

- The performance requirement
- The performance test protocol.

The standard provides listing for each characteristics under test and the clause where the testing is described for normal conditions and for extreme conditions in the Annexes.

IV ANSI N323AB-2013

ANSI N323AB is based on combining two standards into a single standard.

- ANSI N323A addressed issues associated with radcon measurements (radiation worker protection).
- ANSI N323B addressed issues associated with environmental measurements (unrestricted releases for public disposition)

Note: Radcon measurements for “green tagging” items for unrestricted release have been, in fact, environmental measurements without benefit of proper calibration and use protocols.

ANSI N323AB Changes

1. Dose rate instruments

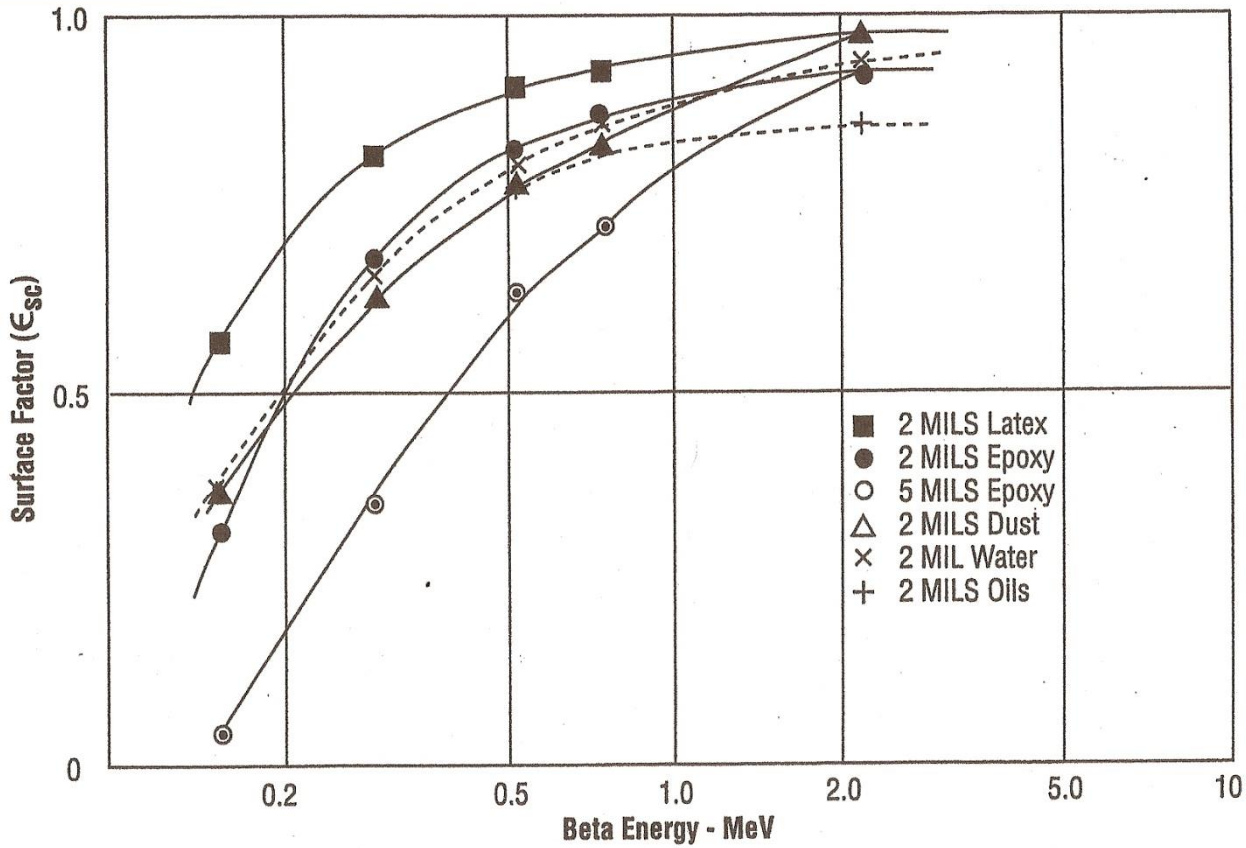
- Modified the scope to reflect new range of applicability for dose rate measurements from 10µR/h to 1000R/h
- Expanded applicability to Homeland Security and emergency response instruments.
- Introduced the concept for extending the calibration frequency interval with five protocols using control charts
- Specified accuracy requirements for dose rate instruments including gamma, beta, and neutron based on operating range.
- Added the provision for calibration range between 10µR/h to 100µR/h using a secondary standard, such as a certified pressurized ion chamber (PIC).

ANSI N323AB Changes

2. Surface contamination instruments

- Calibration source-detector distance should be thr same as field source-detector measurements
- For calibration the use of a point source versus a distributed source should be based on anticipated field issues (hot spots or spill/release).
- Detector efficiency is to be based on certified 2π calibration source emission rates only
- Correcting field measurements using additional field source factors.

Beta Measurement Surface Factor (ϵ_{sc})



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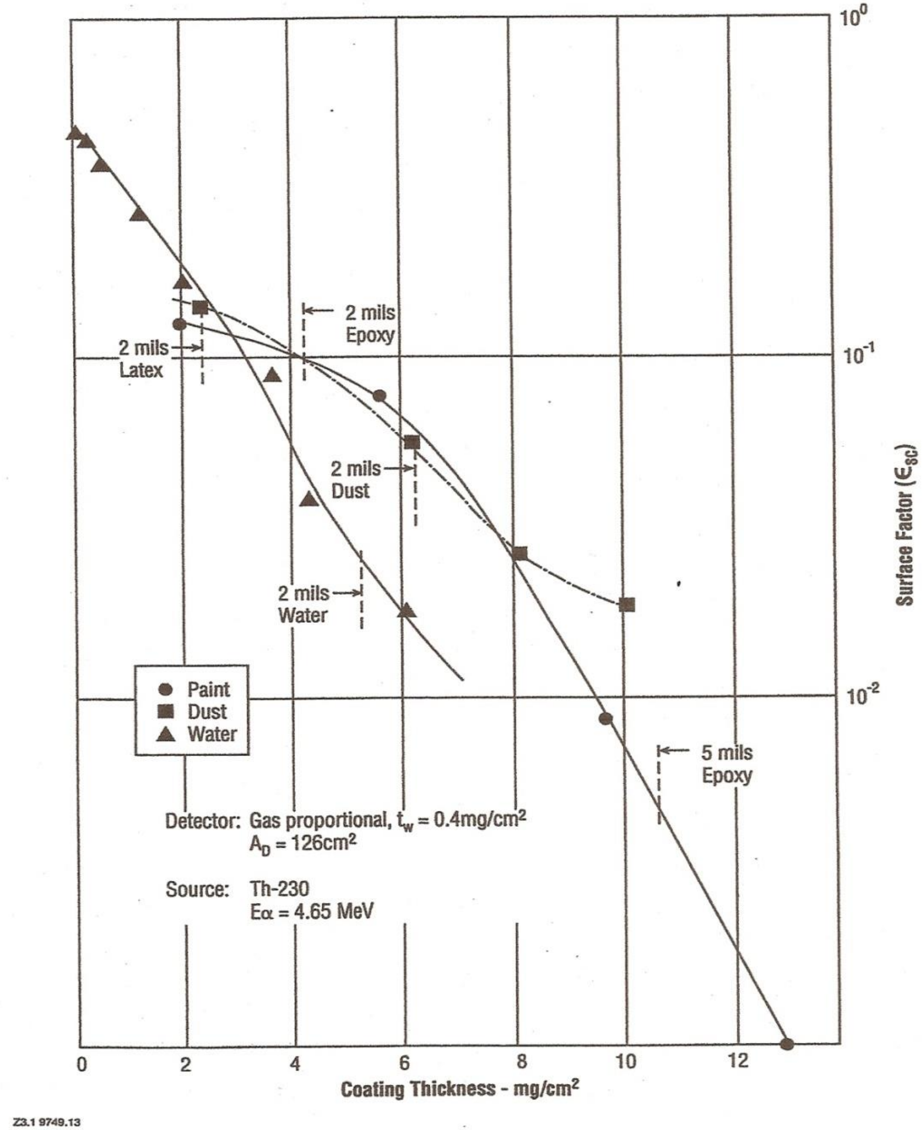
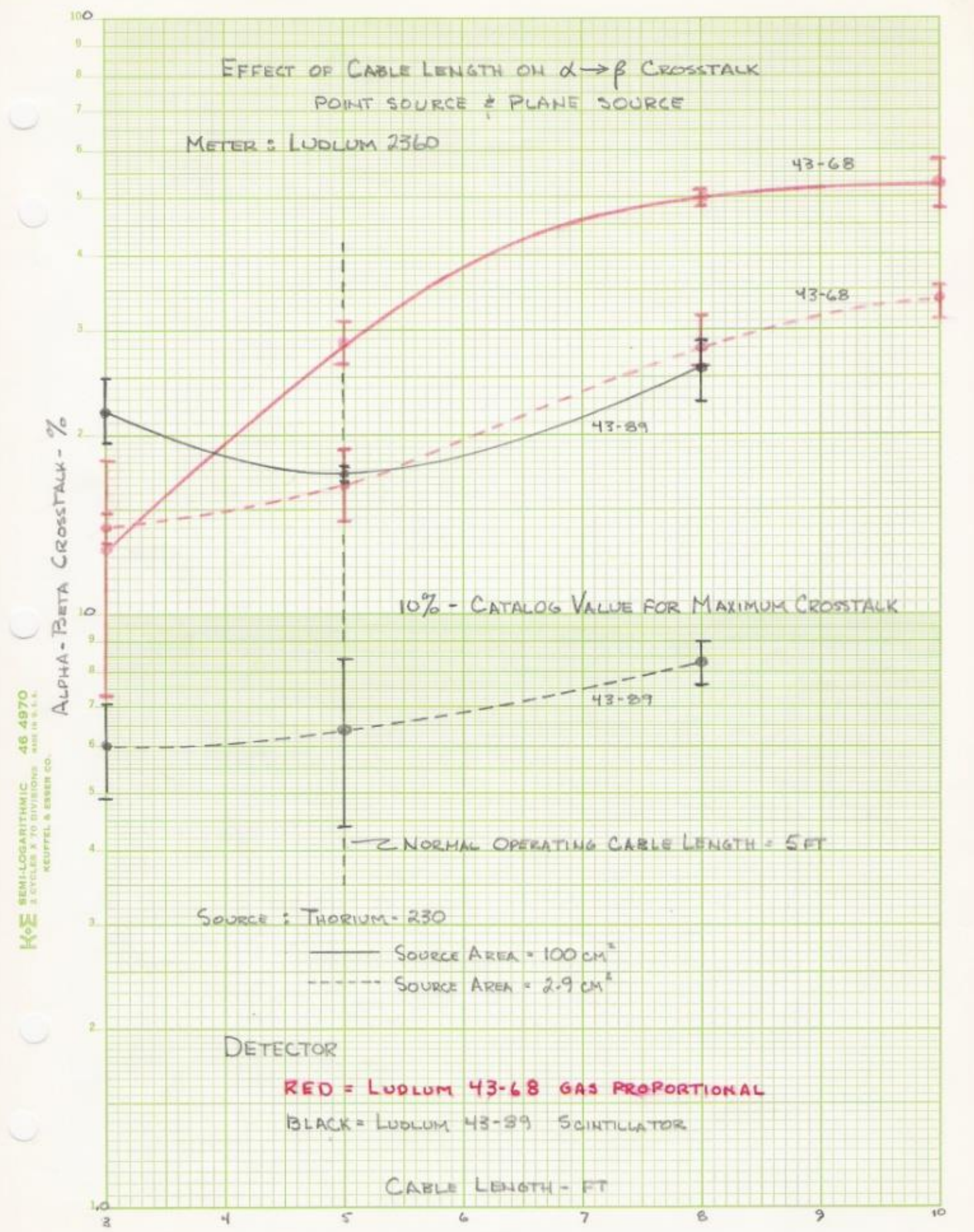
Alpha Measurement Surface Factor (ϵ_{SC})



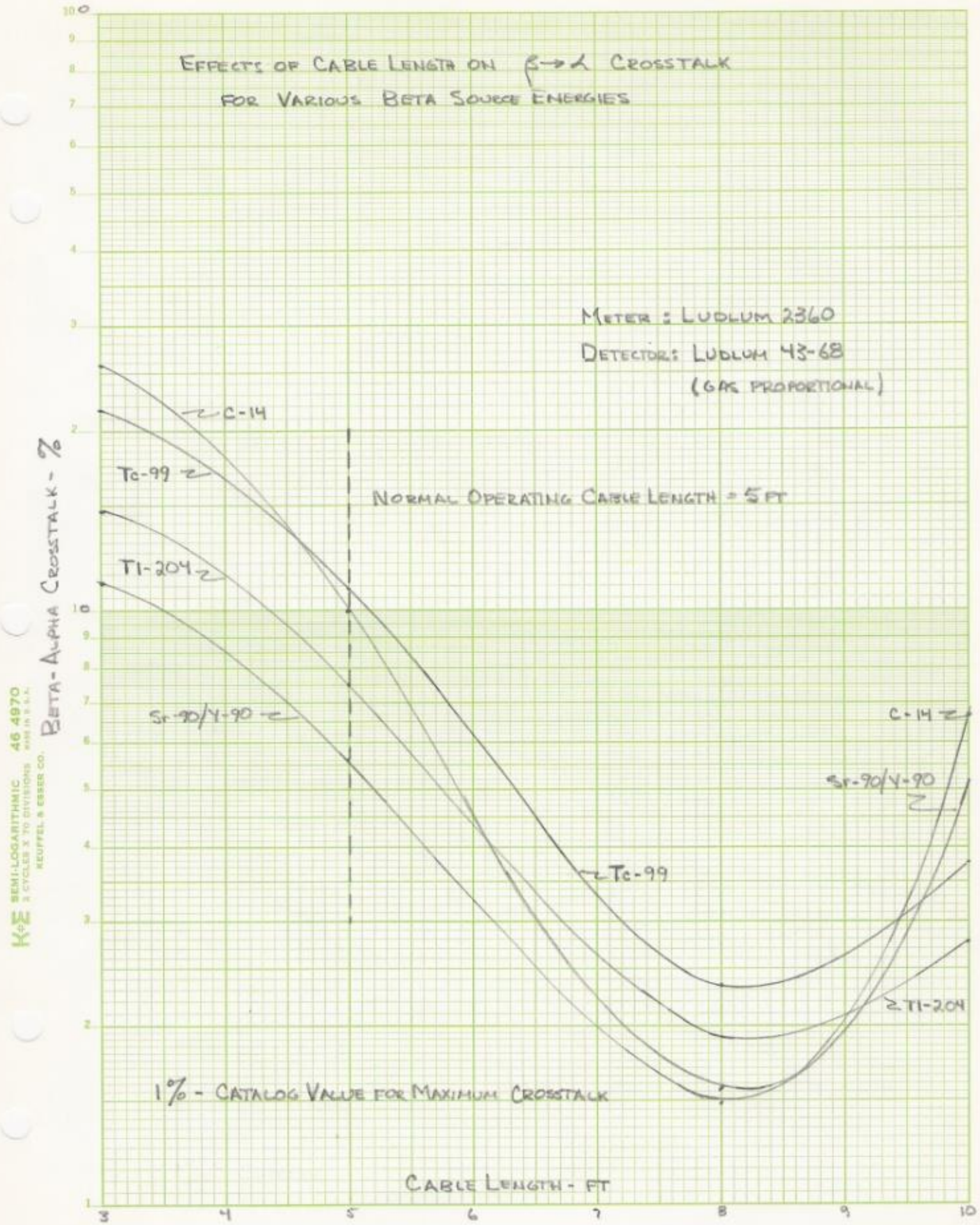
ANSI N323AB Changes

3. Combined alpha-beta contamination instruments

- In addition to instrument efficiency for each channel, the "cross-talk" between channels shall be determined.
- This determination must consider both beta spectrum and cable length effects.



EFFECT OF CABLE LENGTH ON α→β CROSSTALK
POINT SOURCE & PLANE SOURCE
METER : LUDLUM 2360
43-68
43-68
43-89
43-89
10% - CATALOG VALUE FOR MAXIMUM CROSSTALK
NORMAL OPERATING CABLE LENGTH = 5 FT
SOURCE : THORIUM-230
SOURCE AREA = 100 CM²
SOURCE AREA = 2.9 CM²
DETECTOR
RED = LUDLUM 43-68 GAS PROPORTIONAL
BLACK = LUDLUM 43-89 SCINTILLATOR
ALPHA-BETA CROSSTALK - %
CABLE LENGTH - FT
K&E SEMI-LOGARITHMIC 46 4970
KEUFFEL & ESSER CO.


EFFECTS OF CABLE LENGTH ON β→α CROSSTALK
FOR VARIOUS BETA SOURCE ENERGIES
METER : LUDLUM 2360
DETECTOR: LUDLUM 43-68
(GAS PROPORTIONAL)
C-14
Tc-99
Tl-204
Sr-90/Y-90
NORMAL OPERATING CABLE LENGTH = 5 FT
C-14
Sr-90/Y-90
Tc-99
Tl-204
1% - CATALOG VALUE FOR MAXIMUM CROSSTALK
BETA-ALPHA CROSSTALK - %
CABLE LENGTH - FT
3
4
5
6
7
8
9
10
K+E SEMI-LOGARITHMIC 46 4970
2 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO.

ANSI N323AB Changes

4. Hot Swapping

Hot swapping is not recommended under most conditions. If it is to be considered, the following four conditions must be met.

- Voltage must be unchanged for the new combination.

Using response checks, the new combination nust respond within ±20% of the old combination.

- The new combination is not reliant on factors stored in the meter electronics.
- Detector is a GM type.
- Specifically excluded: smart probes.