UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

April 3, 1997

MEMORANDUM TO: Stuart A. Richards, Chief
Operator Licensing Branch

FROM: George M. Usova
Operator Licensing Branch

SUBJECT: TRIP REPORT: WORKSHOP PRESENTATION AT THE REGION III TRAINING SUPERVISORS MEETING

On March 25, 1997, I conducted a four-hour workshop entitled, *Principles and Practices of Measurement and Psychometrics in the NRC Written Examination*, to Region III nuclear power plant training supervisors at a scheduled meeting hosted by COMED in Lombard, Illinois. Approximately 55 participants attended the workshop (See Attachment 1). Also in attendance from the NRC was Mr. Jay Lennartz, a license examiner from Region III. Mr. Lennartz conducted an afternoon question and answer session with the participants.

Background

In December 1996, I was contacted Mr. Paul DiGiovanna of COMED and invited to present a workshop on examination methods to operations training supervisors at their regularly scheduled training supervisors meeting. I had agreed to conduct the workshop and designed the agenda as shown in Attachment 2.

Presentation

As I explained to all workshop participants at the outset of the presentation, the NRC was making this presentation to promote a common understanding between the NRC and industry on measurement concepts and terminology used in examination development and to communicate expectations of levels of knowledge and difficulty in examinations. Because the burden of examination development responsibility was shifting to industry (although the exam is considered to be an NRC administered examination), it was prudent for the NRC to provide to industry the type of guidance contained in the workshop.

This workshop session addressed test item and examination development guidelines established by the operator licensing branch in developing and reviewing operator license examinations. The session also included a background discussion on test validity, defined and assessed higher cognitive level questions, described elements of psychometrics, and provided participant practice in critiquing test items. (See Attachment 3, Workshop Slides).

Several noteworthy questions were raised by the attendees during the presentation and my response follows.

1. Since the NRC wants an exam that intends to discriminate, what percentage of failures does the NRC expect on facility-developed examinations.

My response: The NRC does not have any preconceived expectation on percentage of failures. In fact, given the nature of a criterion-referenced examination, such as that of the NRC license examination in which individuals are tested on the content areas trained upon, the expectation is that scores will generally be high and that most people will pass the examination. Historically, this has been the case. However, occasionally there will be individuals who differ from the norm and will fail the examination; these failures may be attributable to individual differences that exist among people -- differences that manifest themselves in one or more of the following: lower levels of cognitive ability, motivation, aptitude, or personal attention to study and preparation.

On the other hand, the more reliable indicator of an examination's ability to discriminate lies in its average score. In this regard, average scores that fall within the 86-90 range - an expected score range given the fixed cut score and nature of the criterion referenced examination - is a reasonable benchmark for effective discrimination. However, examinations that consistently, and over time, yield average scores exceeding 95, for example, should be reexamined for effective discrimination.

2. What percentage of memory level items are acceptable on an NRC license examination?

My response: The NRC has no fixed percentage of memory level items that should appear on an examination. In general, the more operationally valid an examination, the more likely the examination will contain more items that measure cognitive ability at the higher levels of comprehension, application, and analysis. Realizing that there will likely be some mix of items at all cognitive levels, memory level items should be held to a minimum since they possess less operational and discriminatory validity.

Attachments: As Stated

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On the other hand, the more reliable indicator of an examination's ability to discriminate lies in its average score. In this regard, average scores that fall within the 86-90 range - an expected score range given the 80 percent fixed cut score and nature of the criterion referenced examination - is a reasonable benchmark for effective discrimination. However, examinations that consistently, and over time, yield average scores exceeding 95, for example, should be reexamined for effective discrimination.

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The workshop began at 8:15 and ended approximately at 12:00 P.M. A number of participants made positive and favorable comments about the content presentation during and after the workshop. My overall assessment was that the workshop content and presentation was well received and highly successful.

Attachments: As stated

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March 25, 1997
ComEd's Leadership Development Center

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George Alexander	NRC/HQ	301-415-1064		

Attachment 2

Announcement of next Region III Quarterly (Training Supervisors Meeting Hosted By (

Meeting Information:

Where: ComEd Leadership Development Center (LDC) in Oak Brook Illinois

When: 0730 - 1600, Tuesday, March 25 1997
0730 - 1400, Wednesday, March 26, 1997

Agenda: Day 1

0730-0830	Coffee and...Introductions	
0830-1200	Principles and Practices of Measurement and Psychometrics in the NRC Written Examination. This workshop will address test item and exam development guidelines established by the NRC in developing and reviewing operator license exams. The session will include a discussion and background on test validity, define and assess higher cognitive level questions, describe elements of psychometrics, and provide practice in critiquing acceptable and unacceptable items	Dr. George Usova, NRC Training and Assessment Specialist
1200-1300	Lunch	
1300-1500	Discussion of Rev 8 issues/ Draft Rev 8 Additional Reg III examiners will discuss recent pilot exam experiences	J. Lenhartz, Reg III NRC Acting Chief Operator Licensing Branch
1500-1600	Questions and Open Discussion (ILT and Requal)	

Agenda, Day 2

0730-0830 Coffee and...

Submit ideas/needs for day 2 agenda. Items that will be discussed are recent INPO visits, resource exchange program, etc. A detailed agenda will follow.

Suggested attendance would include the operations training supervisor and your initial exam developer.

Due to the expected high level of attendance, I will need a reply by Feb. 28, 1997 stating the number of attendees per utility/site. Please contact me at 815-458-3411 x 2218, or shwpd@comail.ceco.com. (the sooner the better, especially if you have input to the agenda)

Look forward too seeing you all soon

Paul DiGiovanna
ComEd

PRINCIPLES AND PRACTICES OF MEASUREMENT AND PSYCHOMETRICS IN THE NRC WRITTEN EXAMINATION

TRAINING SUPERVISOR'S WORKSHOP
MARCH 25, 1997

George M. Usova
Training and Assessment Specialist
USNRC
301-415-1064

ATTACHMENT 3

WORKSHOP OUTCOMES

- Common terminology
- Common understanding
- Shared expectations

  - Less rework
  - Better examination product

SESSION OBJECTIVE:

To review validity concepts affecting the NRC written examination for the purpose of:

instructing facility personnel toward the construction of more valid and consistent NRC license examinations

COVERAGE

- 3 Levels of Validity
- 3 Levels of Knowledge
- Discrimination, Sampling, and Cut Scores
- Psychometrics

VALIDITY

A valid test is one which tests what it intends to test.

In *training* examinations, this means it tests the specific skills and knowledge defined and taught in the objectives.

In *licensing* examinations, this means it tests the specific skills and knowledge that *should* have been defined and taught in the objectives.

3 LEVELS OF VALIDITY

- Content
- Operational
- Discriminant

CONTENT VALIDITY

Essentially addresses K/A coverage and

sampling plan coverage

OPERATIONAL VALIDITY

Addresses two questions:

1. Is the question, as stated, important to be known as a part of the operator's job?

2. Does the question, as expressed, require the candidate to perform a job related mental or physical operation?

DISCRIMINANT VALIDITY

Addresses making a distinction of measurement along a continuum of candidate performance.

- **The cut score is the exam performance level that the test yields for making a pass-fail decision.**
- **Since the cut score is 80 percent, the exam must be written at a level of difficulty that *intends* to discriminate at the 80 percent level.**
- **The test item, its stem and distractor, interplay are such that, *by intent and design*, at least 80 percent of the candidates taking the test should answer the item correctly.**

VALIDITY SUMMARY

1. The exam (item) must be content valid, which encompasses job safety significance and sampling.

2. The exam (item) should be operationally oriented: a conceivable mental or psychomotor performance of the job. As such the item should be written at the comprehension or analysis level vice simple fundamental knowledge; this means items that measure problem solving, prediction, and analysis--central to job performance.

3. The exam (item) must discriminate at a moderate level of difficulty as set by the cut score. This means that the stem and distractor interplay are such that at least 80 percent of the candidates taking the test should answer the item correctly.

3 LEVELS OF KNOWLEDGE

Bloom's Taxonomy

- Analysis, Application, Synthesis
- Comprehension
- Fundamental (simple memory)

LEVEL OF KNOWLEDGE

- Bloom's Taxonomy is the reference benchmark NRC uses to classify the levels of knowledge of test items.
- Bloom's Taxonomy is a classification scheme that permits the classification of items by the level (depth) of mental thought and performance required to answer the items.
- Bloom's Taxonomy conceptually can be applied to written, scenarios, or JPM items.

LEVELS DEFINED

LEVEL 1

Fundamental Knowledge testing is defined as a simple mental process that tests the recall or recognition of discrete information bits with concrete referents; examples include knowledge of terminology, definitions, set points, or other specific facts.

LEVEL 2

Comprehension testing involves the mental process of understanding the material through relating it to its own parts or to some other material; examples can include rephrasing information in different words, describing or recognizing relationships, showing similarities and differences among parts or wholes, recognizing how systems interact, including consequences or implications.

LEVEL 3

Analysis, synthesis, and application testing is a more active and product-oriented testing which involves the multi-part mental process of assembling, sorting, or integrating the parts (information bits and their relationships) so that the whole, and the sum of its parts can be used to: predict an event or outcome, solve a problem, or create something new, i.e., mentally using the knowledge and its meaning to solve problems.

DETERMINANTS OF DISCRIMINATION

- Level of examination knowledge
- Level of examination difficulty
- Passing score
- Item bank use

NATURE OF EXAMINATIONS AND TESTS

- Tests are samples of performance
    - Infer overall performance based upon sample
    - Sample must be broad-based to make confident inference
    - Sample must not be fully predictable otherwise inferences cannot be made on untested areas
    - Items must intend to discriminate otherwise test has little or no value

PSYCHOMETRICS

Items may have one or more of the following psychometric errors:

1. **Low level of knowledge (fundamental knowledge)**
2. **Low operational validity (not clearly job operational)**
3. **Low discriminatory validity (too easy or too hard)**
4. **Implausible distractors**
5. **Confusing language or ambiguous questions**
6. **Confusing or inappropriate negatives in the question**
7. **Collection of true/false statements**
8. **Backward logic**

LOW LEVEL OF KNOWLEDGE

Which one of the following is powered from 4160 VAC bus 1A?

a. RHR pump A*
b. RHR pump B
c. RHR pump C
d. RHR pump D

LOW LEVEL OF KNOWLEDGE

Select the full core display indication of a drifting control rod.

a. Red light*
b. White light
c. Blue light
d. Amber light

LOW LEVEL OF KNOWLEDGE

Concerning use of water as a fire extinguishing agent, SELECT the correct statement from the following:

a. Primary agent for extinguishing Class A fires and also effective on Class B and C fires *

b. Primary agent for extinguishing Class B fires band also effective on Class A and C fires

c. Primary agent for extinguishing Class A and B fires but not effective on Class C fires

d. Primary agent for extinguishing Class B and C fires but not effective on Class A fires

This level of knowledge is low because it doesn't test the candidate's ability to recognize what class a fire is then to select the correct extinguisher then use it. All the candidate needs to know is that water is for class A.

LOW LEVEL OF KNOWLEDGE

The following plant conditions exist:

- o RCP 2A tripped after running for 50 minutes.
- o The RCP was restarted, but tripped within 15 seconds.

Which ONE of the following is the minimum required interval before the next attempt to start RCP 2A?

a. 15 minutes
b. 30 minutes*
c. 45 minutes
d. 60 minutes

The above question might be considered a fundamental knowledge level that is too hard unless the operators are expected to know the correct time requirement in order to preclude damage to equipment.

LOW OPERATIONAL VALIDITY

Under which one of the following conditions should the Shift Supervisor inform the shop steward?

a. Initiation of a directed overtime request
b. Discipline action on a supervisory personnel
c. Medical injury of a contractor personnel
d. Personnel error by a bargaining unit member*

While this may be related to a SS's job, it has nothing to do with nuclear safety and should not be included in an NRC examination.

LOW DISCRIMINATORY VALIDITY

Which one of the following reactor water levels will initiate the RHR pumps?

a. Level 1 only*
b. Level 1 and 2 only
c. Level 1 and 2 and 3 only
d. Level 6 only

This information should be known by 100% of all operators at all times and is of low discriminatory validity.

LOW DISCRIMINATORY VALIDITY

The plant is recovering from a scram due to a spurious Group I isolation. The cause of the isolation has been repaired and preparations are being made to reopen the MSIVs. Reactor pressure is currently 825 psig and the main steam lines are being pressurized.

WHICH ONE (1) of the following represents the LOWEST main steam line pressure that will allow the MSIVs to be opened per procedure?

a. 625 psig
b. 675 psig*
c. 725 psig
d. 775 psig

This question doesn't discriminate because in real life the applicant wouldn't be expected to have memorized the procedure and as such would be low in operational validity.

IMPLAUSIBLE DISTRACTORS

Which of the following will cause the RHR pumps to start during a design basis LOCA?

a. Low drywell pressure
b. High reactor water level
c. High drywell pressure*
d. MSIVs in the NOT OPEN position

Distractors a, b, and d are implausible distractors considering minimal knowledge of the plant response to a LOCA.

CONFUSING OR INAPPROPRIATE NEGATIVES IN THE QUESTION

Regarding temporary plant alterations (TPA), technical reviews are NOT required

a. for a TPA NOT installed using an approved procedure.
b. for TPAs installed on BOP systems but are required for safety related systems.
c. for a TPA that has NOT been directed by the shift supervisor to be an emergency TPA.
d. for all TPAs directed by the shift supervisor.

This question contains multiple problems: (1) While negative questions can be used, they should be used for good reason; in the above example, there appears to be no good basis for asking this question negatively. (2) Two of the distractors (a and c) also contain a negative, creating a double negative and readability confusions, a violation of good item writing practice.

This question would be more appropriately written as "Under which of the following conditions are technical reviews required?" This phrasing would eliminate the negative in the stem.

COLLECTIONS OF TRUE/FALSE STATEMENTS

Which of the following are true?

a. High drywell pressure will auto start the emergency diesel generators.*
b. Low reactor water level will trip the main turbine.
c. High reactor pressure will initiate RCIC.
d. High reactor power with the mode switch in startup will NOT close the MSIVs.

COLLECTIONS OF TRUE/FALSE STATEMENTS

Which one of the following describes pump cavitation?

a. Vapor bubbles are formed when the enthalpy difference between pump discharge and a pump suction exceeds the latent heat of vaporization.
b. Vapor bubbles are formed in the eye of the pump and collapse as they enter higher pressure regions of the pump.*
c. Vapor bubbles are produced when the localized pressure exceeds the vapor pressure at the existing temperature.
D. Vapor bubbles are discharged from the pump where they impinge on downstream piping and cause a water hammer.

Both examples represent an error of a collection of true/false statements, which typically only test simple rote memory; the candidate needs only to recall a definition or condition. The question elicits no comprehension or problem-solving; hence, the question lacks operational validity. This type of question allows a candidate to answer the question without the stem of the question.

BACKWARD LOGIC

Backward logic is a question that asks the candidate for information normally received, and provides the candidate with information he/she normally has to supply. In an operational setting, operators are faced with conditions and required to know what procedure(s) to use. Instead the question asks them to do just the opposite.

BACKWARD LOGIC

Which of the following parameters will simultaneously start HPCI, RCIC and SBGTS?

a. High RPV water level

b. High drywell pressure*

c. Low RPV water level

d. Low drywell pressure

It is better to select a parameter and then request the expected system response because that is more operationally relevant.

BACKWARD LOGIC - an everyday example

"If it takes 12.5 cubic feet of concrete to build a square loading pad 6 inches thick, what is the length of one side of the pad?"

This question gives the test takers information they should be asked to calculate, while it requires them to provide information they would be supplied in an actual work situation.

PSYCHOMETRIC GUIDELINES FROM EXAMINER STANDARDS

Multiple-Choice Items

a. Does the question have one focused topic, making it something other than a collection of true-false items?

b. Is as much information as possible included in the stem?

c. Is the question or problem defined in the stem?

d. Are tricky or irrelevant questions avoided?

e. Are the answer options homogeneous and highly plausible?

f. Are "none of the above" and "all of the above" avoided?

g. Are there an appropriate number of options for each question?

h. Is each item stated positively, unless the intent is to test knowledge of what not to do?

i. Is the question free of "specific determiners" (e.g., logical or grammatical inconsistencies, incorrect answers which are consistently different, verbal associations between the stem and the answer options)?

j. Are common misconceptions used as distractors?

k. Are the answer options of the items ordered sequentially?

l. Is the question free of trivial distractors?

NRC CHECKLIST FOR OPEN-REFERENCE TEST ITEMS

Test Item Level

____ 1. Does each test item have a documented link to important licensee tasks, K/As, and/or facility learning objectives?

____ 2. Is each question operationally oriented (i.e., is there a correlation between job demands and test demands)?

____ 3. Is the question at least at the comprehension-level of knowledge?

____ 4. Is the context of the questions realistic and free of window dressing and backwards logic?

____ 5. Does the item require an appropriate use of references (i.e., use of analysis skills or synthesis of information either to discern what procedures were applicable or to consult the procedures to obtain the answer)?

____ 6. Is the question a "direct look-up" question, or does one question on the examination compromise another? A "direct look-up question" is defined as a question that immediately directs an licensee to a particular reference where the answer is readily available.

____ 7. Does the question possess a high K/A importance factor (3 or greater) for the job position?

____ 8. Does the question discriminate a competent licensee from one who is not?

____ 9. Is the question appropriate for the written examination and the selected written examination format (e.g., short answer; multiple choice)?

____ 10. Do questions in Section A take advantage of the simulator control room setting?

____ 11. Does any question have the potential of being a "double-jeopardy" question?

____ 12. Is the question clear, precise, and easy to read and understand?

____ 13. Is there only one correct answer to the question?

____ 14. Does the question pose situations and problems other than those presented during training?

____ 15. Does the question have a reasonable estimated response time?

COMPREHENSION

APPLICATION

OR

MEMORY?

Dr. George M. Usova
Training and Assessment Specialist
USNRC

COMPREHENSION/APPLICATION OR MEMORY LEVEL?

Q: When is a comprehension/application level question NOT likely a comprehension/application level question?

There are several categories of misapprehension or misconception of what distinguishes a fundamental simple memory level question from that of a higher cognitive level question.

Although the facility never argued that Example below was more than memory level, its revision was argued as an application level question.

EXAMPLE:

As required by 10 CFR 26, "Fitness for Duty Programs," what is the MINIMUM time an operator must abstain from the consumption of alcohol prior to any scheduled shift?

a. 2 hours
b. 3 hours
c. 5 hours
d. 8 hours

Answer: c K/A 294001K1.05 - memory

Evaluation. The above question is clearly a fundamental knowledge level question since it elicits from memory a simple detail/fact.

REVISION

You were called this morning and requested to assist with a unit startup this evening. To enter the plant at 11 PM that evening, what is the LATEST time that you could consume alcohol?

a. 2 PM
b. 4 PM
c. 6 PM
d. 8 PM

Answer: c

Evaluation. Although the revised question required the secondary mental process of *subtraction* to arrive at the correct answer, the ancillary process of subtraction is only an intervening step that slightly complicates the process of arriving at the correct answer. Subtraction is required to answer the question but is unrelated to the knowledge required of a competent operator.

COMPREHENSION/APPLICATION OR MEMORY LEVEL?

EXAMPLE:

While performing surveillance procedure W1 on the Unit-1, division-2 125 VDC battery, you obtain the following data:

- ICV: 2.14
- Temperature: 86 degrees F
- Level: -1 (as recorded)
- Specific Gravity (uncorrected): 1.201
- Battery Charger Current: 5 amps on float

$$\text{S.G. (corrected)} = \text{S.G. (uncorrected)} + \frac{(T - 77 \text{ degrees F})(.001)}{3}$$

+ (Level Mark)(.003)

Based on the above information, the Specific Gravity is _____ which _____ meet the Technical Specification Category A limit.

Note: This question requires the use of TS 3.8.2.3.

a. 1.198, does NOT
b. 1.195, does NOT
c. 1.207, does
d. 1.201, does

Answer: d K/A 295004G008 (Application)

Evaluation. This question might appear to test the applicant's ability to understand and apply battery parameters to the determination of TS operability. However, as one can plainly see, the question only tests the applicants to substitute certain parameters into a given equation and perform an arithmetic calculation. Reference to the TS noted in the question is not required based on the three different values of S.G. (corrected) supplied as distractors. Therefore, the question is of no discriminatory value since any individual possessing adequate arithmetic knowledge will arrive at the correct answer.

COMPREHENSION/APPLICATION OR MEMORY LEVEL?

The facility argued that the question below was at the comprehension level. Since the question was not asking the expected, memorized set point of 110 F, the change to 112 F elevated the thought process beyond the memory level.

EXAMPLE

In response to a stuck open SRV, which of the following conditions would <u>require</u> scramming the reactor?

a. SRV tailpipe temperature reaches 350 degrees F.
b. Two cyclings of the SRV's handswitch were unsuccessful.
c. One minute has elapsed since the SRV first opened.
d. Suppression pool temperature is 112 degrees F.

Answer: d

Evaluation. Although TS limits are 110 degrees F, raising the number by 2 degrees to 112 does not meaningfully elevate the level of knowledge to a higher, more operationally valid level where relationships are interrelated and decision-making is required.

COMPREHENSION/APPLICATION OR MEMORY LEVEL?

EXAMPLE

The example below may or may not be at the comprehension level. It can represent a more subtle example that might is projected as comprehension but upon closer inspection is simply the extraction of verbatim text from a "Discussion" segment of training/reference material.

In response to a major leak in the Instrument Air system, the operators have scrammed the reactor with the reactor mode switch taken to SHUTDOWN.

As the Instrument Air System pressure continues to decrease, what will be the effect on the MSIVs?

Inboard MSIVs	Outboard MSIVs
a. Remain open	Will close
b. Will close	Remain open
c. Will close	Will close
d. Remain open	Remain open

Answer: a

REF: Abnormal operating procedure, Loss of Instrument Air and/or Service Air, Page 3, Section E, Discussion.

Evaluation. Because the material was drawn from a discussion session does not automatically elevate its level of knowledge. If the response asked for in the test item requires the candidate to independently interrelate a causal relationship that is not directly addressed in the material, then the question is truely at the comprehension level. On the other hand, if the causal relationship is *directly* presented as such in either textual material or classroom training, and is then again *directly* represented as such in a test item, there is arguably no individual independent comprehension mental process occuring. The question has been relegated to a verbatim recognition/recall level.