

# Supplemental Guidance for Writing Effective Multiple Choice Questions

## Purpose

The purpose of this document is to provide supplemental guidance on writing effective multiple choice questions to examiners and licensees who develop and review Operator Licensing written exams.

## Scope

This document provides clarifications and guidance for fulfilling the intent of 10 CFR 55 Subpart E and NUREG 1021, as they pertain to written test items. The use of this document is not a regulatory requirement and shall be used on a voluntary basis. The following provisions are applicable:

1. This document does not impose any requirements or expectations on licensees beyond those in NUREG 1021.
2. This document does not replace or eliminate the requirements within NUREG 1021.
3. Anyone discovering a conflict between this guidance and NUREG 1021 should consider bringing it to the attention of the responsible NRC Region Office or the Headquarters (HQ) Program Office.
4. NUREG-1021 always takes precedence if a conflict is identified.

## References

1. K/A catalogs (NUREG 1122 and NUREG 1123)
2. 10CFR55, Subpart E - Written Examinations and Operating Tests.
3. NUREG 1021, Rev. 9, Supplement 1, "Operator Licensing Examination Standards For Power Reactors" Appendix B
4. Operator Licensing Feedback Web page questions 401.2, 401.3, 401.16, 401.48, and Gen 8 @ <http://www.nrc.gov/reactors/operator-licensing/op-licensing-files/ol-feedback.pdf>
5. MANTG/NRC Conference August 2005 & Licensee Operator Licensing Workshop presentation (ADAMS Accession Number ML052790507)
6. 2007 MANTG – Flawed Test Items (ADAMS Accession Number ML073130392)
7. 2008 Region III NRC & Licensee Operator Licensing Workshop presentation (ADAMS Accession Number ML090970297)
8. 2011 Region II Exam Writers' Conference, "the Subset Issue Correcting a Common Psychometric Flaw" (ADAMS Accession Number ML112240240)

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## Supplemental Guidance for Writing Effective Multiple Choice Questions

### I. What is an Implausible Distractor?

Plausible: *reasonable, appearing worthy of belief*

Implausible: *provoking disbelief*

[Source: Merriam Webster's Collegiate Dictionary - Tenth Edition]

An implausible Distractor can be defined as an answer choice that can be quickly eliminated by someone with little or no knowledge of the topic being tested. For example, an answer choice could be considered implausible if it:

- is composed of relatively unimportant information along with other choices that focus on more important concepts (trivial Distractor); or
- does not grammatically follow from the stem (specific determiners); or
- contains words such as "always" or "never" which suggest an incorrect option.

NUREG-1021, Revision 9, Supplement 1, ES-401, Section C.2.b, states that an implausible Distractor is a "psychometric flaw."

Form ES-401-9, Written Examination Review Worksheet, Item 3 states that single implausible Distractors should be repaired; more than one is unacceptable.

### II. Examples of Implausible Distractors

#### A. Requires Minimal Plant Knowledge

Which one of the following will cause the RHR pumps to start during a large break 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 because the choices can be all represent safe conditions when compared to Choice C; therefore, the question can be answered with minimum knowledge of the initiating signals for the LOCA logic.

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### B. Fails Common Sense Test

Why does the procedure titled "Reactor Refueling Operations" **allow stopping all operating RHR pumps for up to 1 hour per 8-hour period** during the performance of core alterations?

- A. To allow for swapping of RHR trains in service.
- B. To facilitate movement of fuel or core components.**
- C. RHR cooling is not required at all by Technical Specifications with the pool flooded.
- D. To obtain Spent Fuel Pool heat up data to verify Time to Boiling calculations.

Distractor C is not plausible because it is unrealistic for RHR cooling being *not required at all* by Technical Specifications while in refueling, especially when one considers boron mixing, decay heat removal, etc.

Given the following conditions:

- Reactor Power is 100%
- Pressurizer level is 56% and rising
- Pressurizer pressure is 2235 psig and slowly rising
- Letdown flow isolates
- Charging flow rises
- Annunciator 32B, PZR 17% HTRS OFF, alarms
- Annunciator 32C, PZR LO LEV DEV, alarms
- All containment parameters are normal

Which ONE (1) of the following has occurred?

- A. Reactor Coolant System Leak.
- B. Pressurizer Level Channel Failure.**
- C. Loss of Charging.
- D. Letdown Line Break.

Distractors A, C and D are not plausible because the 2<sup>nd</sup> bullet in the stem indicates that pressurizer level is slowly rising.

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Given the following plant conditions:

- Reactor power is 100%
- Pressurizer pressure channel I(429), has been removed from service for surveillance testing with its' associated bi-stables tripped
- Pressurizer pressure channel IV (449), fails LOW

Which ONE of the following describes the initial automatic system response?

- A. Reactor trip, but NO Safety Injection;  
Pzr PORV PR-2A remains closed
- B. Reactor trip and Safety Injection;  
Pzr PORV PR-2A remains closed**
- C. Reactor trip but NO Safety Injection;  
Pzr PORV PR-2A opens
- D. Reactor trip and Safety Injection;  
Pzr PORV PR-2A opens

The second portion of Distractors C and D is not plausible because the 3<sup>rd</sup> bullet that states that the Pressurizer pressure channel fails low; there is no reason for a Pzr PORV to open

### C. Physics not Correct

Torus water temperature rises from 75 °F to 95 F over several weeks due to summer heat.

Which of the following describes the effect of the rise in torus water temperature?

- A. The INCREASE in torus airspace would result in LOWER post-LOCA peak drywell pressure.
- B. The DECREASE in torus water level would result in LOWER available NPSH for the ECCS pumps.
- C. The DECREASE in torus airspace would result in HIGHER post-LOCA peak drywell pressure.**
- D. The INCREASE in torus water level would result in HIGHER available NPSH for the ECCS pumps.

Distractors A and B are not plausible since it is commonly known that water expands when heated over this temperature range; therefore, an increase in torus air space or a decrease in torus water level is impossible.

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### D. Distractors Conflict with Information in Question Stem

The plant is operating at 100% power.

A failure of the governor/pressure regulator occurs which causes the turbine control valves to fully open.

Given the above conditions, which one of the following RPS trip signals will cause an automatic scram?

**A. Main Steam Isolation Valve Closure**

B. APRM flux - Upscale

C. Low RPV water level

D. Turbine Control Valve Closure

Distractor D is not plausible because the stem states that the turbine control valves have failed open.

Additionally, Distractor B is minimally plausible because an increase voids always adds negative reactivity.

### E. Distractors Not Independent From Each Other (Subsets)

This is the most common plausible Distractor problem, but is the easiest to fix by using an appropriate modifier to eliminate the “subset”.

The Plant is in MODE 3.

Which one of the following is the Reactor Coolant System (RCS) UNIDENTIFIED leak rate that results in LCO 3.4.13, RCS Operational LEAKAGE, to be NOT met?

A. Any nonzero leak rate.

B. 0.2 gpm.

**C. 1.1 gpm.**

D. 10.1 gpm.

If one erroneously believed NO IDENTIFIED LEAKAGE is allowed, all 4 answers would be correct because Distractors B, C, and D are subsets of Distractor A. To eliminate the subset issue, Distractor A should be revised to “Any nonzero leak rate < 0.2 gpm.”

Similarly, since IDENTIFIED LEAKAGE must be limited to 1.0 gpm, Distractor C is correct. However, Distractor D is also correct because both answers are greater than 1 gpm.

This can be fixed by adding the modifier “MINIMUM” to the stem.

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The final version:

The Plant is in MODE 3.

Which one of the following is the **MINIMUM** Reactor Coolant System (RCS) UNIDENTIFIED leak rate that results in LCO 3.4.13, RCS Operational LEAKAGE, to be NOT met?

- A. Any nonzero leak rate < 0.2 gpm.
- B. 0.2 gpm.
- C. 1.1 gpm.**
- D. 10.1 gpm.

### III. Making Distractors More Plausible

Distractors can be plausible by incorporating misconceptions about the topic. For example, in the following question pertaining to loss of subcooling margin, Distractors A, C, and D use these common misconceptions to create plausible Distractors.

Which one of the following identifies the reason why the reactor coolant pumps (RCPs) are required to be secured during a small break LOCA when subcooling margin is lost?

- A. to prevent pump damage resulting from operation under two-phase conditions
- B. to prevent core damage resulting from rapid phase separation upon subsequent loss of RCS flow**
- C. to reduce RCS pressure by removing the pressure head developed by the RCPs
- D. to remove heat being added to the RCS by the operating RCPs

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Another way to make Distractors more plausible is to use two part answer options. For example, in the following question, two part answer options of *what* and *why* are used.

Given the following conditions:

- A LOCA has occurred and the crew has entered OP-902-002, Loss of Coolant Accident Recovery
- RCS pressure is 600 PSIA
- HPSI pump A & B are running and all Safety Injection Flow Control valve are open
- Cold leg injection header flow rates are as follows:
  - 1A is 190 gpm
  - 1B is 160 gpm
  - 1C is 175 gpm
  - 1D is 0 gpm
- Fifteen minutes into the event, RVLMS indicates core uncover and CETs are showing superheat.

Based on the above indications, the crew should (1) because (2)?

- | (1)  | (2)   |
|--|---|
| A Remain in OP-902-002, LOCA Recovery            | Core uncover and superheated conditions are expected            |
| B Remain in OP-902-002, LOCA Recovery            | The SI flow curves are met                                      |
| C Exit to OP-902-008, Functional Recovery        | Core uncover and superheated conditions are <u>NOT</u> expected |
| <b>D Exit to OP-902-008, Functional Recovery</b> | <b>The SI flow curves are NOT met</b>                           |

Distractor A is credible because for some LOCA events (such as the one described in the stem), core uncover and superheated conditions are expected.

Distractor C is credible because core uncover and superheated conditions normally indicate inadequate core heat removal which requires transitioning to a Functional Recovery procedure.

However, in this case, transitioning to a Functional Restoration is required because Safety Injection flow is only 535 gpm which is below the design flow of 600 gpm (150 gpm per header) needed to adequately remove core heat.

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### IV. Examples of Improved Multiple Choice Questions

#### Westinghouse: System 061 Auxiliary/Emergency Feedwater

#### K2.02 Knowledge of bus power supply to the following: AFW electric drive pumps

##### BEFORE (Minimal Plant Knowledge):

The plant is operating at 100% power with EDG #1 on clearance for a lube oil change-out. Subsequently,

- An inadvertent reactor trip occurs COINCIDENT with a loss of offsite power.
- All SG levels “Shrink” to 10% narrow range

Which one of the following predicts the auxiliary feedwater pump that will be running including the electrical bus that will be providing the power to the pump?

- A. “A” AFW pump powered from 480V Bus 8N
- B. “A” AFW pump powered from 4KV Bus 2AE
- C. “B” AFW pump powered from 480V Bus 9P
- D. “B” AFW pump powered from 4KV Bus 2DF**

Distractors “A” and “B” can be easily eliminated by knowing EDG # 1 is the Train A emergency power supply.

##### AFTER:

This question is now an application level question because the applicant must *predict the outcome* of the event described in the stem. This question requires the applicant to recall automatic start signals to both the steam driven and the motor driven pumps in addition to power supplies to the motor driven AFW pumps.

The plant is operating at **25%** power with EDG #1 on clearance for a lube oil change-out. Subsequently,

- An inadvertent reactor trip occurs COINCIDENT with a loss of offsite power.
- All SG levels “Shrink” to **25%** narrow range

Assuming no operator actions are taken, which one of the following predicts the auxiliary feedwater (AFW) system response

- A. NO AFW pumps are running
- B. ONLY the Steam Driven AFW pump is running
- C. ONLY the “B” AFW pump is running
- D. BOTH the Steam Driven AFW pump AND “B” AFW pump are running**

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### Westinghouse: System 063 DC Electrical Distribution

#### K2.01 Knowledge of bus power supply to the following: Major DC loads

BEFORE (Specific Determiners - Cueing):

Which one of the following identifies the effect, if any, to DG-1A following a loss of DC bus 11A?

- A. Loss of ALL engine protective tripping capability
- B. Loss of Normal and Emergency engine start circuits**
- C. No effect, DG-1A remains FUNCTIONAL from bus 11C
- D. Loss of ALL engine operating parameters indications from any location.

Distractors A, C and D are weak Distractors due to the absolute nature of the responses (ALL, no effect, ALL)

AFTER:

The plant is at 100% power and all systems are in a normal alignment. Power is lost to Vital 125 VDC bus 11A

What effect, if any, will a loss of bus 11A have on DG-1A?

- A. The DG will NOT start on a Safety Injection signal**
- B. The DG will start and run unloaded on a Loss of Offsite Power signal
- C. The DG will NOT start automatically or manually from the MCB, but can be started from the local diesel control panel.
- D. After DG-1A is started, it will NOT trip on an overspeed condition

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### GE BWR-4: Refueling Accidents

#### AK1.01 – Knowledge of the operational implications of the following concepts as they apply to REFUELING ACCIDENTS: Radiation Accidents

BEFORE: Baseless Distractors – Distractors C & D use 26.5 feet. There is no reason behind this water level in the Accident Analysis, Technical Specification Bases or plant procedures.

The plant is in MODE 5, **REFUELING**

Which **ONE** of the following is the **MINIMUM** acceptable Water Level above the Reactor Vessel Flange, **AND** the reason for that limit?

- A. **20.5 feet provides adequate iodine absorption following an accident.**
- B. 20.5 feet provides adequate shielding of personnel during core alterations.
- C. 26.5 feet provides adequate iodine absorption following an accident.
- D. 26.5 feet provides adequate shielding of personnel during core alterations.

#### AFTER:

Distractors C & D use the Spent Fuel Pool Level (over the spent fuel racks) required by Technical Specifications.

With the plant in MODE 5, REFUELING, with Core Alterations in progress.

Which **ONE** of the following is the **MINIMUM** acceptable Water Level above the Reactor Vessel Flange, and the reason for that limit?

- A. **20.5 feet provides adequate iodine absorption following an accident.**
- B. 20.5 feet provides adequate shielding of personnel during core alterations.
- C. 22.0 feet provides adequate iodine absorption following an accident.
- D. 22.0 feet provides adequate shielding of personnel during core alterations.

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### Westinghouse: System 015 DC Electrical Distribution

**AK3.07 Knowledge of reasons for the following response as they apply to the Reactor Coolant Pump Malfunctions (Loss of RC Flow): Ensuring that S/G levels are controlled properly for natural circulation enhancement.**

#### BEFORE:

Given the following:

- Unit 3 was operating at power when a Loss of Offsite Power occurred.
- The operating crew has implemented 3-EOP-ES-01, Reactor Trip Response.
- Stable plant conditions have been completed.
- Offsite power is expected to be restored within 24 hours.

In accordance with 3-EOP-ES-0.1, which one of the following describes (1) the control band used for S/G levels and (2) the reason for that band?

- A. BETWEEN 15% AND 50% to preclude AFW re-initiation and establish a heat sink which will enhance natural circulation.**
- B. BETWEEN 32% AND 50% to preclude AFW re-initiation and establish a heat sink which will enhance natural circulation.
- C. BETWEEN 15% AND 50% to maintain an adequate inventory to start a natural circulation cooldown.
- D. BETWEEN 32% AND 50% to maintain an adequate inventory to start a natural circulation cooldown.

#### AFTER:

Distractors B and D are now more credible with containment temperature elevated. Otherwise, there is no reason to pick the control band associated with adverse containment parameters.

Given the following:

- Unit 3 was operating at power when a Loss of Offsite Power occurred.
- The operating crew has implemented 3-EOP-ES-01, Reactor Trip Response.
- RCS Pressure is 2210 psig and stable.
- Pressurizer Level is 35% and lowering.
- Containment temperature is 105°F.
- Offsite power is expected to be restored within 24 hours.

In accordance with 3-EOP-ES-0.1, which one of the following describes (1) the control band used for S/G levels and (2) the reason for that band?

- A. BETWEEN 15% AND 50% to preclude AFW re-initiation and establish a heat sink which will enhance natural circulation.**
- B. BETWEEN 32% AND 50%% to preclude AFW re-initiation and establish a heat sink which will enhance natural circulation.
- C. BETWEEN 15% AND 50% to maintain an adequate inventory to start a natural circulation cooldown.
- D. BETWEEN 32% AND 50% to maintain an adequate inventory to start a natural circulation cooldown.