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NPTEL ONLINE
CERTIFICATION COURSE

Failure Analysis and Prevention

Industrial Engineering Tools for FA: Fault Tree Analysis

DHEERENDRA KUMAR DWIVEDI
MECHANICAL & INDUSTRIAL ENGINEERING DEPARTMENT



Fault Tree Analysis

- A structured team analysis of the possible underlying causes of a known equipment failure.
- root cause analysis of a failure is needed
- A better understanding of the root causes of a failure
- A better set of action plans to eliminate those root causes



Fault Tree Analysis...

- Fault tree analysis is cause and effect diagram
- Uses standard symbols developed in the defense industry
- A structured approach for analyzing the **root causes** of a failure mode not yet fully understood.
- Better suited for understanding layers and relationships of causes of equipment failures.



FTA Procedure

- **Probable** causes are identified:
 - The team constructed the FTA around the three major categories in the functional block diagram, inputs, process, and outputs.
 - The team continued to build the FTA and completed it by adding lower levels of detail under appropriate causes of failure.
 - The team identified the types of failure where it did not have the **expertise** to analyze possible root causes. If deemed necessary, the team would seek help from suppliers or consultants to further analyze these area.
 - **The leading causes of failure and solutions were identified.**
- A design project was started to correct the problem.



Symbols for Fault Tree Diagram

- Symbols Review

- Square



Describes the top and lower level

- Or Gate



Produces output (failure) if
one or more inputs exist

- And Gate



Produces output (failure) if
and only if **all** inputs exist

- Circle



Potential root failure which cannot be
broken down into lesser failures

- Diamond



Potential failure which is not
analyzed for various reasons

How to build a Fault Tree

- 1) Identify a top failure
- 2) Brainstorm basic contributors to failure
- 3) Link contributors to the top failure
 - Determine which combination of contributors is needed to cause the top failure. (Ask: How many of the inputs are needed to cause the top failure?)
 - Link the contributors to the top failure with the correct gate.
(And/Or)



Ask: Can we determine contributors for this lower failure ?

- **Yes** - repeat cycle making each contributor a top failure, assign gates, etc...
- **No** - we are finished - We may also end our fault tree when we reach all indeterminable, basics, or causes which require further research etc...

Understanding the symbols (Gates Review)

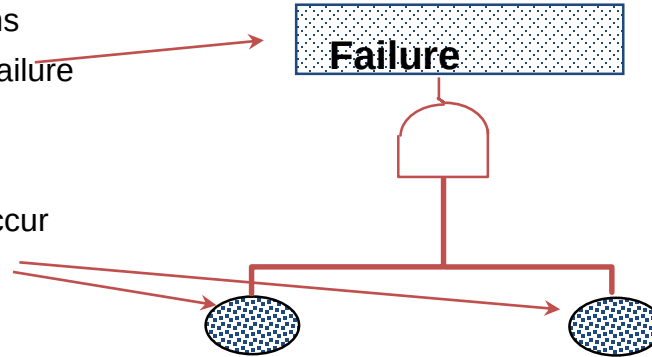
And gate means

For this upper failure

to occur

All of these

failures must occur



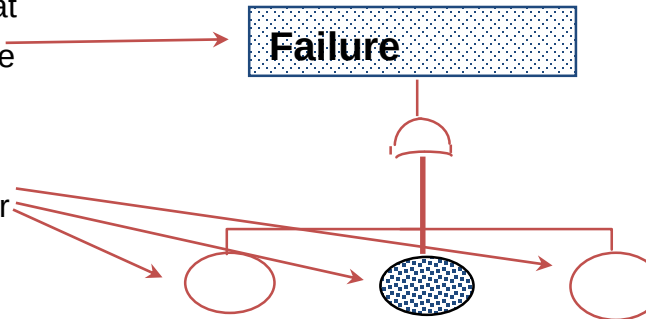
Or gate means that

or this upper failure

to occur

Only one of these

failures must occur



Step 1 Identify Top Level Fault

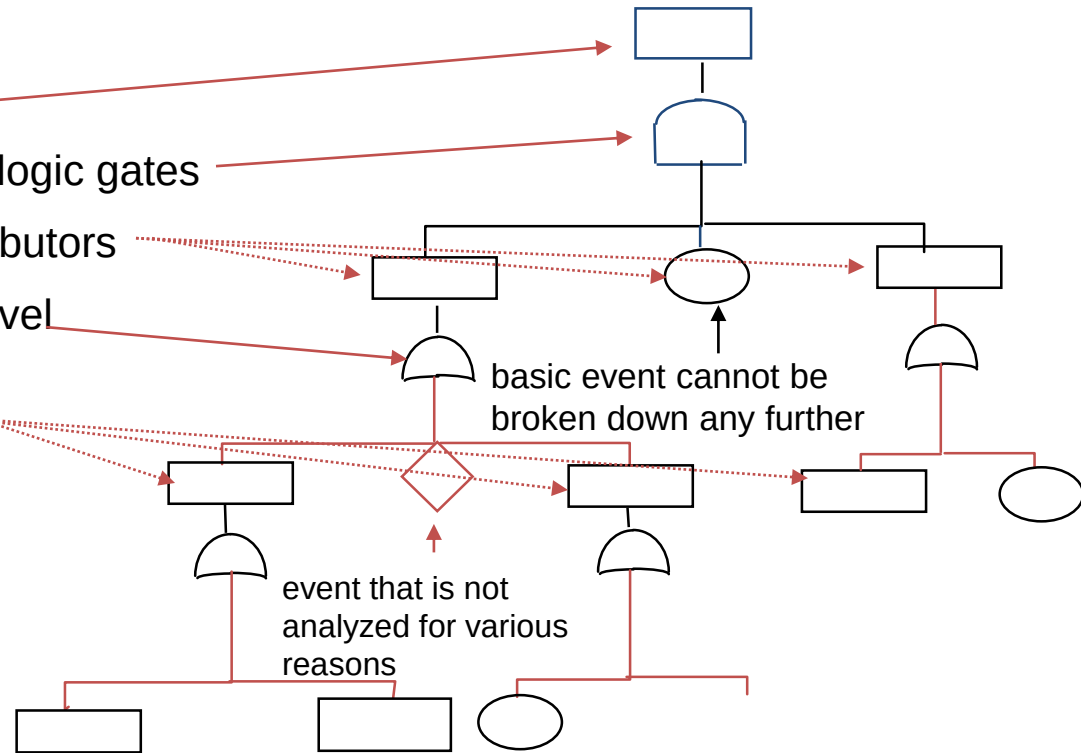
Step 3 Link contributors to top by logic gates

Step 2 Brainstorm first level contributors

Step 5 Link contributors to upper level by logic gates

Step 4 Brainstorm second level contributors

Step 6 Repeat / continue for each lower level failure



Typical application of FTA for Smoke alarm

- Begin by clearly **identifying** the failure as: The indicator light is on ... yet even with sufficient amounts of smoke directly below the detector vents the alarm does not signal.
- Began **brainstorming** and building a functional block diagram to fully understand how the smoke detector functions.
- Continued brainstorming on **possible** causes for the smoke detector failure resulting in the alarm not signaling.



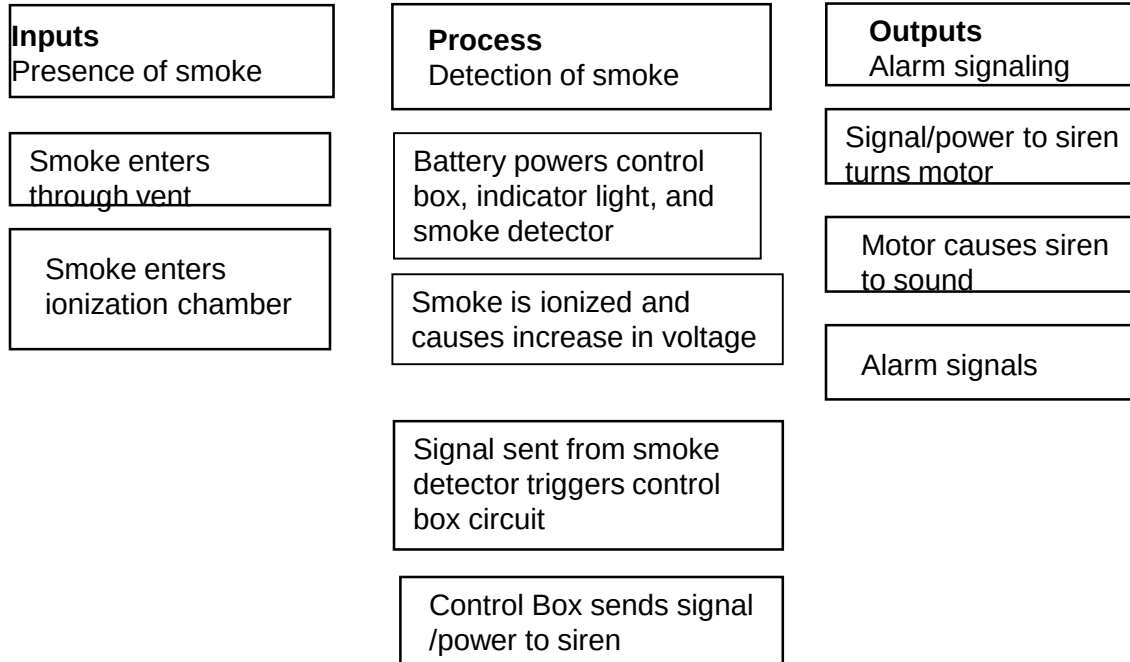
FTA Example: Smoke Detector

- **Failure:** The indicator light is on... yet even with sufficient amounts of smoke directly below the detector vents the alarm does not signal.

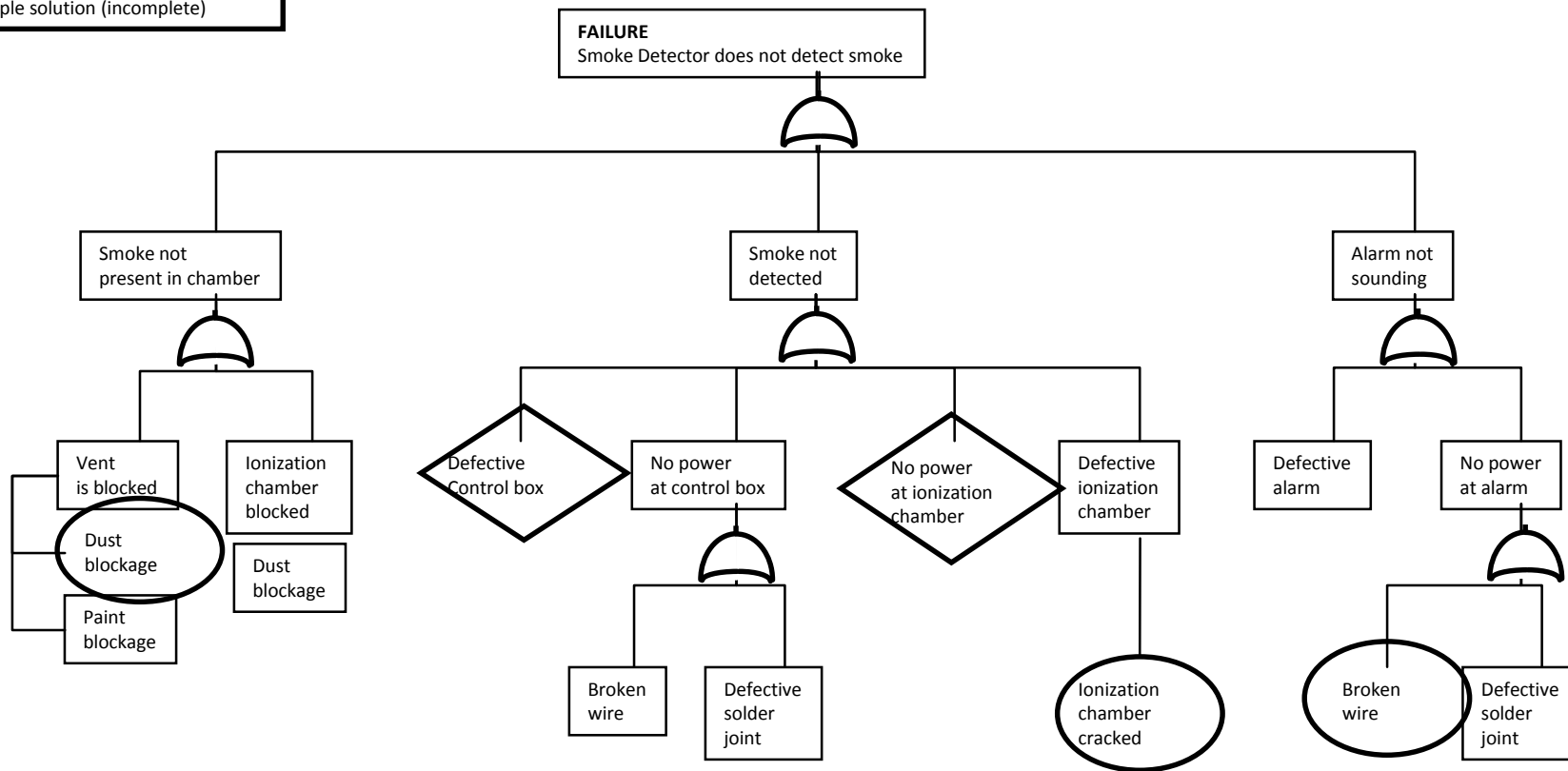
Before we begin a Fault Tree Analysis, our first step should be to construct a Functional Block Diagram.



FBD Example: Smoke Detector

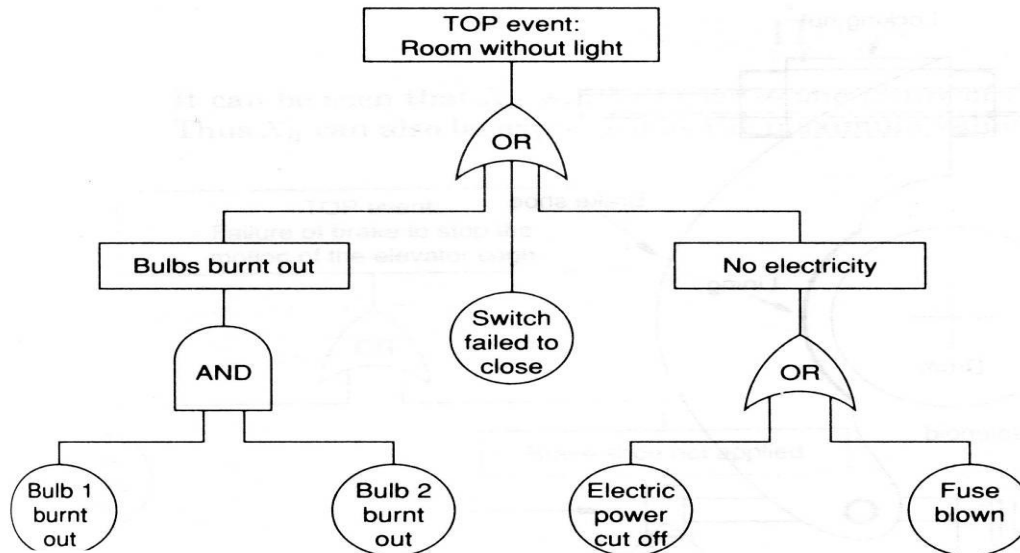


Sample solution (incomplete)



Consider a room containing two light bulbs operated by a single switch (see By assuming the “room without electric light” as the undesirable (top) event, construct a fault tree of the system.

solution The top event can occur due to the occurrence of any of the three input events, namely, “bulbs burnt out,” “switch failed to close,” and “no electricity.” This solution can be represented by a three-input OR gate. The occurrence of the events “bulbs burnt out” and “no electricity” can be investigated further. The event “bulbs burnt out” occurs when both the bulbs are burnt out and so the situation can be represented by a two-input AND gate. The event “no electricity” occurs when electric power is cut off or the fuse is blown, and the situation can be represented by a two-input OR gate. The resulting fault tree is shown in Fig. 13.14.



Construction of a fault tree.

FTA Do's & Don'ts

- Do's
 - Start at the Top
 - Think Categories
 - Brainstorm, then organize
 - Facilitate proper brainstorming
 - Know when to stop
 - Have action plans for all circles
 - Check that branches terminate with a circle or diamond
 - Revisit the FBD or FTA when new data is found
- Don'ts
 - Don't get *bogged down*
 - Don't jump to solutions!

