"Capacity Building and Strengthening Institutional Arrangement"

Workshop: Quantitative risk assessment of oil and gas plants

Eu and Italian Methodologies for Major Hazards Quantitative Risk Assessment

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Italian methodologies for major hazards quantitative risk assessment

The role of risk assessment

A PLANT IS A DYNAMIC REALTY,
THEREFORE ALSO RISK ASSESSMENT
HAS TO BE CONSIDERED IN
A DYNAMIC AND
ARTICULATED PERSPECTIVE.

VARIABLES TO BE
TAKEN INTO ACCOUNT:

- SOURCES OF RISK
- ASPECTS OF RISK
- TIME

SOURCES OF RISK

RISKS MAY BE ORIGINATED BY:

- RAW MATERIALS (INCLUDING THEIR PRODUCTION AND TRANSPORTATION)
- PLANT ITSELF
- WASTE DISPOSAL
- PRODUCTS (INCLUDING THEIR TRANSPORT AND USE)
- FINAL PLANT DECOMMISSIONING

EACH ONE OF THESE ITEMS REPRESENTS A DIFFERENT PHASE OF THE WHOLE PRODUCTIVE CYCLE.

SO, SOMETIME, THE RISK CORRELATED TO A PRODUCTION MAY MANIFEST ITSELF IN PLACES OTHER THAN THE PLANT OR IN TIMES OTHER THAN THE PRODUCTION.

RISK FEATURES

THE RISK AND ITS CONTROL
MAY BE PERTINENT AT LEAST TO THREE
DIFFERENT BUT NOT INDIPENDENT
FIELDS OF INTEREST:

- TECHNICAL
- ECONOMIC
- SOCIO/POLITICAL

IT IS NOT FEASIBLE TO LOOK OUT
FOR SOLUTIONS INVOLVING
ONE FEATURE ONLY.
IT IS NECESSARY TO KEEP
A COMPREHENSIVE VISION
OF THE PROBLEMS.

MOREOVER, EACH FEATURE IS
A COMBINATION OF SEVERAL FACTORS
TO BE TAKEN INTO ACCOUNT.
FOR INSTANCE, THE TECHNICAL FEATURE
WILL CONSIDER THE FOLLOWING:

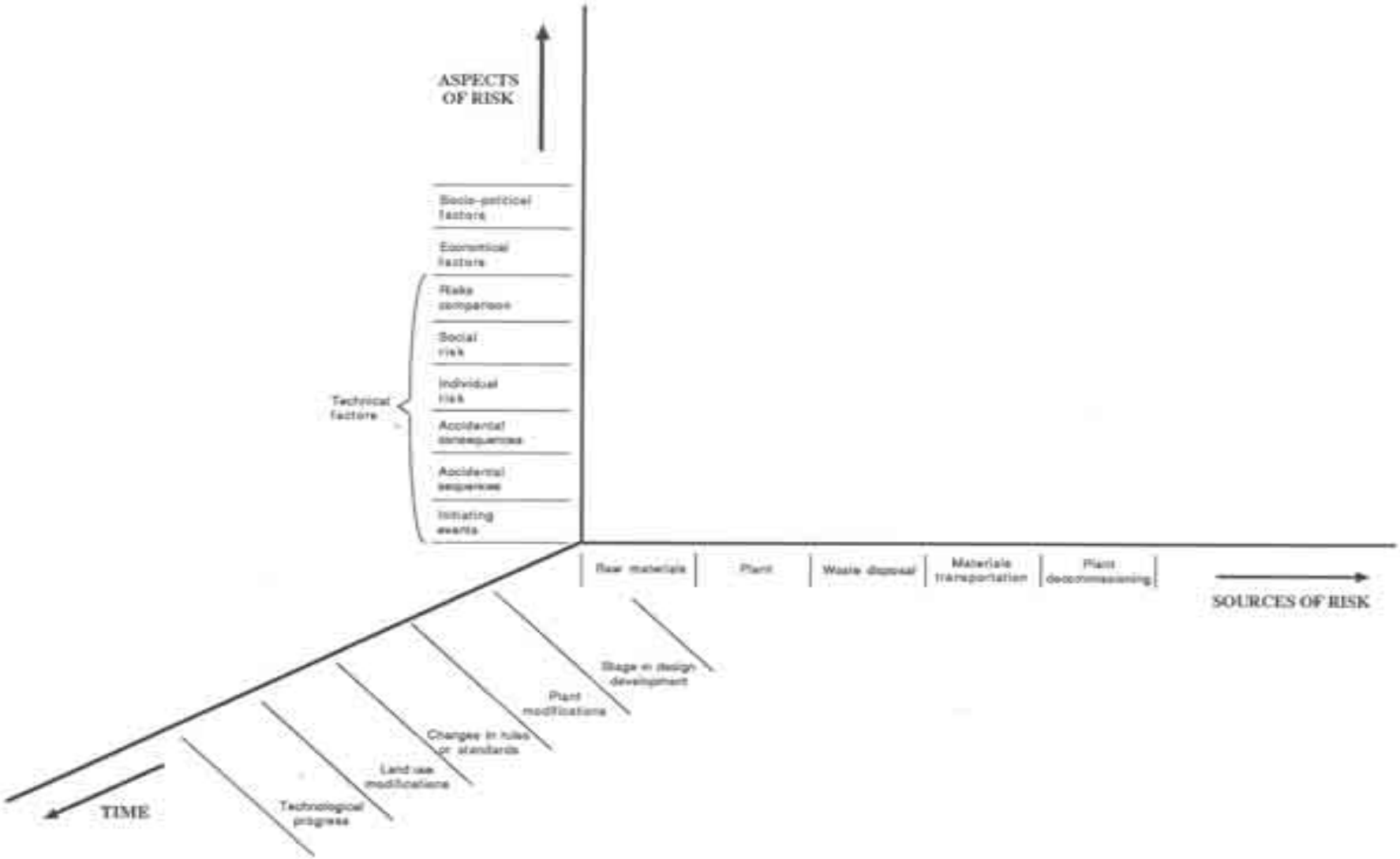
- INITIATING EVENTS
- ACCIDENTAL SEQUENCES
- ACCIDENTAL CONSEQUENCES
- INDIVIDUAL RISK
- SOCIAL RISK
- RISKS COMPARISON

TIME

SOME OF THE FACTORS
INFLUENCING THE RISK MAY VARY
MEANINGFULLY WITH THE TIME:

- STAGE IN DESIGN DEVELOPMENT
- PLANT MODIFICATIONS
- CHANGES IN RULES OR STANDARDS
- LAND USE MODIFICATIONS
- TECHNOLOGICAL PROGRESS
- ETC.

THEREFORE THE RISK ITSELF,
IN LEVEL AND SOMETIME IN QUALITY,
WILL BE TIME DEPENDENT.



MATRIX OF THE FACTORS RELEVANT TO THE RISK ASSESSMENT.
(adapted from Consultancy - Risk Assessment for Hazardous Installations, 1986)

THE STRUCTURE TO BE GIVEN TO A RISK ASSESSMENT MAY DEPEND ON THE SPECIFIC FINALIZATION:

1. REGULATORY

A. ASSESSMENTS PERFORMED OR REQUIRED BY CONTROL AUTHORITIES

- TO PRELIMINARILY DECIDE IF A RISK MAY BE RELEVANT OR NOT
- TO VERIFY THE FITNESS WITH REGULATIONS AND JUSTIFY EVENTUAL CONTROL ACTIONS
- TO DEMONSTRATE INFRINGEMENTS OF REGULATIONS
- TO SUPPORT JUDICIAL PROCEEDINGS
- FOR LICENSING
- TO CONTROL THE SUBSISTANCE OF PREREQUISITES AND THE RESPECT OF PRESCRIPTIONS

B. ASSESSMENTS PERFORMED BY THE MANUFACTURER OR THIRD PARTIES

- TO MEET REGULATORY REQUIREMENTS
- TO ANSWER SPECIFIC QUESTIONS PUT BY CONTROL AUTHORITIES
- TO SUPPORT JUDICIAL PROCEEDINGS
- TO APPLY AGAINST ADMINISTRATIVE ACTIONS

2. IN SUPPORT TO MANAGEMENT

A. MARKETING

* TO PROVE A PRODUCT OR A PROCESS BEING NOT HAZARDOUS
* TO PROVE A PRODUCT OR A PROCESS MAY ENSURE HIGHER SAFETY STANDARDS IN RESPECT WITH THE COMPETING OR ALTERNATIVE ONES

B. PLANNING

* RESEARCH AND DEVELOPMENT
  - TO ANTICIPATE REGULATORY REQUIREMENTS
  - TO REDUCE THE POSSIBILITY OF FUTURE CLAIMS
  - TO REDUCE OWN LEVEL OF RESPONSIBILITY
  - TO SEARCH NEW MARKETS FOR RISK CONTROL TECHNOLOGIES
  - TO IMPROVE ANALYTICAL CAPABILITIES
* OPTIMIZATION IN THE USE OF RESOURCES
* ASSESSMENT OF ALTERNATIVE TECHNOLOGIES

C. RISK MANAGEMENT

* TO PREVENT AND MITIGATE ACCIDENTS
* TO REDUCE LIABILITY AND LEGAL OR FINANCIAL RISKS
* TO REDUCE INSURANCE PREMIUM

3. FORMATION

A. INFORMATION TO THE POPULATION

* TO PROMOTE A RATIONAL ATTITUDE IN THE PUBLIC OPINION
* TO MEET REGULATORY REQUIREMENTS

B. TRAINING

* OPERATORS
* INTERVENTION TEAMS

Italian methodologies for major hazards quantitative risk assessment

Analytical approach and methodologies in industrial risk assessment

THE RISK ASSESSMENT MAY BE BASED ON:

REACTIVE APPROACH

DETERMINISTIC, IT HAS BEEN ALWAYS USED IN THE INDUSTRIAL PRACTICE

PREDICTIVE APPROACH

EXPLICITLY INTRODUCED FOR THE FIRST TIME IN THE INDUSTRIAL PRACTICE BY ROBENS REPORT, IT HAS BEEN OUTLINED AND REGULATED BY ACMH AND THE EEC DIRECTIVES

THE PREDICTIVE APPROACH DOES NOT INTEND TO REPLACE THE REACTIVE ONE.

THE CONCRETE EXPERIENCE GAINED IN DESIGN AND OPERATION OF PLANTS WILL ALWAYS REMAIN AN UNREPLACEABLE ELEMENT.

REACTIVE APPROACH

- IS BASED ON THE PAST EXPERIENCE
- CONSISTS IN THE APPLICATION OF:
  - ENGINEERING CODES AND STANDARDS
  - REGULATIONS
  - CHECK LISTS
  - SAFETY REVIEWS
  - CASE HISTORIES (DATA BANKS)
- IDENTIFIES THE DEVIATIONS FROM TECHNICAL SPECIFICATIONS OR OTHER PREDETERMINED SOLUTIONS OR ALREADY KNOWN SITUATIONS
- IN OTHER TERMS, ASSURES THE CONTROL OF THE RISKS BY VERYING THE RESPECT OF THE "STATE OF THE ART"

EXPERIENCES GAINED IN DIFFERENT AREAS

(DESIGN, CONSTRUCTION, COMMISSIONING, OPERATION, DECOMMISSIONING, EMERGENCY HANDLING)

ARE CONVERTED TO

CODES, STANDARDS, RECOMMENDATIONS, SPECIFICATIONS, PROCEDURES, REGULATIONS

THEY ARE THE BASIS OF THE "GOOD ENGINEERING" PRACTICE, AND ITS HISTORICAL EVOLUTION.

MOST OF THESE EXPERIENCES
FORM A "KNOW-HOW",
OFTEN A CONFIDENTIAL ONE,
OF THE GREAT MANUFACTURERS
(ICI, EXXON, UNION CARBIDE, ENI, ETC.)
AND OF THE MOST QUALIFIED
ENGINEERING SOCIETIES
(KELLOG, TECHINT, CTIP, SNAMPROG. ETC.).

ON A MINOR EXTENT THEY ARE
PART OF AN "OPEN" KNOWLEDGE,
IN MOST CASES ARRANGED IN FORM OF
MONOGRAPHIC CODES,
AT LOCAL OR INTERNATIONAL LEVEL,
PUBLIC OR CORPORATIVE.

SOME EXAMPLES OF THE LAST:

- **ASME CODES**
  BOILERS AND PRESSURE VESSELS
- **API STANDARDS**
  MACHINERY AND EQUIPMENT,
  PLANT LAY OUT,
  PROCESS INSTRUMENTATION AND CONTROL SYSTEMS,
  OVERPRESSURE PROTECTIONS,
  BLOW-DOWN SYSTEMS,
  ETC.
- **ISA STANDARS**
  CONSTRUCTION, CALIBRATION AND INSTALLATION OF PROCESS INSTRUMENTATION
- **N.E. CODES (NEC)**
  EXPLOSION PROOFING OF ELECTRICAL EQUIPMENT
  AREA CLASSIFICATION
- **NFPA CODES (NFC)**
  FIRE PREVENTION AND PROTECTION

TECHNIQUES FOR THE IDENTIFICATION OF DEVIATIONS FROM "GOOD ENGINEERING" PRACTICE:

- **CHECK LISTS**
  - GENERAL
  - SPECIFIC FOR ARGUMENT OR COMPETENCE
  - BROAD
  - DETAILED

- **SAFETY REVIEWS**
  - BRAINSTORMING (SINERGY)
  - AUDIT (CROSS CHECKING)
  - IN-HOUSE
  - INDIPENDENT

LIMITATIONS DUE TO:

- UNFEASIBILITY TO IDENTIFY HAZARDS AT LOW PROBABILITY, BUT POSSIBLY WITH SEVERE CONSEQUENCES

- NO GUARANTY THAT ALL RISKS HAVE BEEN SISTEMATICALLY TAKEN INTO CONSIDERATION

- UNFEASIBILITY TO ADEQUATLY DEAL WITH NEW PROCESSES OR SITUATIONS

ON THE OTHER SIDE:

- RAPID DEVELOPMENT OF DESIGN AND OPERATIONAL TECHNIQUES, SOMETIMES AT A VERY HIGH LEVEL OF COMPLEXITY AND VARIETY
- RAPID GROWTH OF THE INDUSTRIAL ACTIVITIES IN NUMBER AND SIZE
- GREATER CROWDNESS IN LAND USE, WITH CONSEQUENTLY INCREASED VULNERABILITY OF POPULATION AND ENVIRONMENT
- GREATER AWARENESS OF THE HAZARDS ASSOCIATED WITH MANY CHEMICAL SUBSTANCES

- MAJOR ACCIDENTS OCCURED IN THE RECENT YEARS

- GREATER CONSCIOUSNESS AND SENIBILITY OF THE PUBLIC, DUE ALSO TO A HIGHER STANDARD OF LIFE

THEY ALL ARE FACTORS WICH HAVE LED TO THE IMPLEMENTATION OF A NEW APPROACH (ANALYTICAL AND PREDICTIVE), ON SOME EXTENT MORE ADEQUATE THAN THE TRADITIONAL ONE, AND OVERCOMING SOME OF ITS GREATEST LIMITATIONS.

INTER ALIA, THIS ATTITUDE HAS IMPRINTED THE SPECIFIC REGULATIONS ISSUED IN THE RECENT TIME FOR THE CONTROL OF RISKS.

PREDICTIVE APPROACH

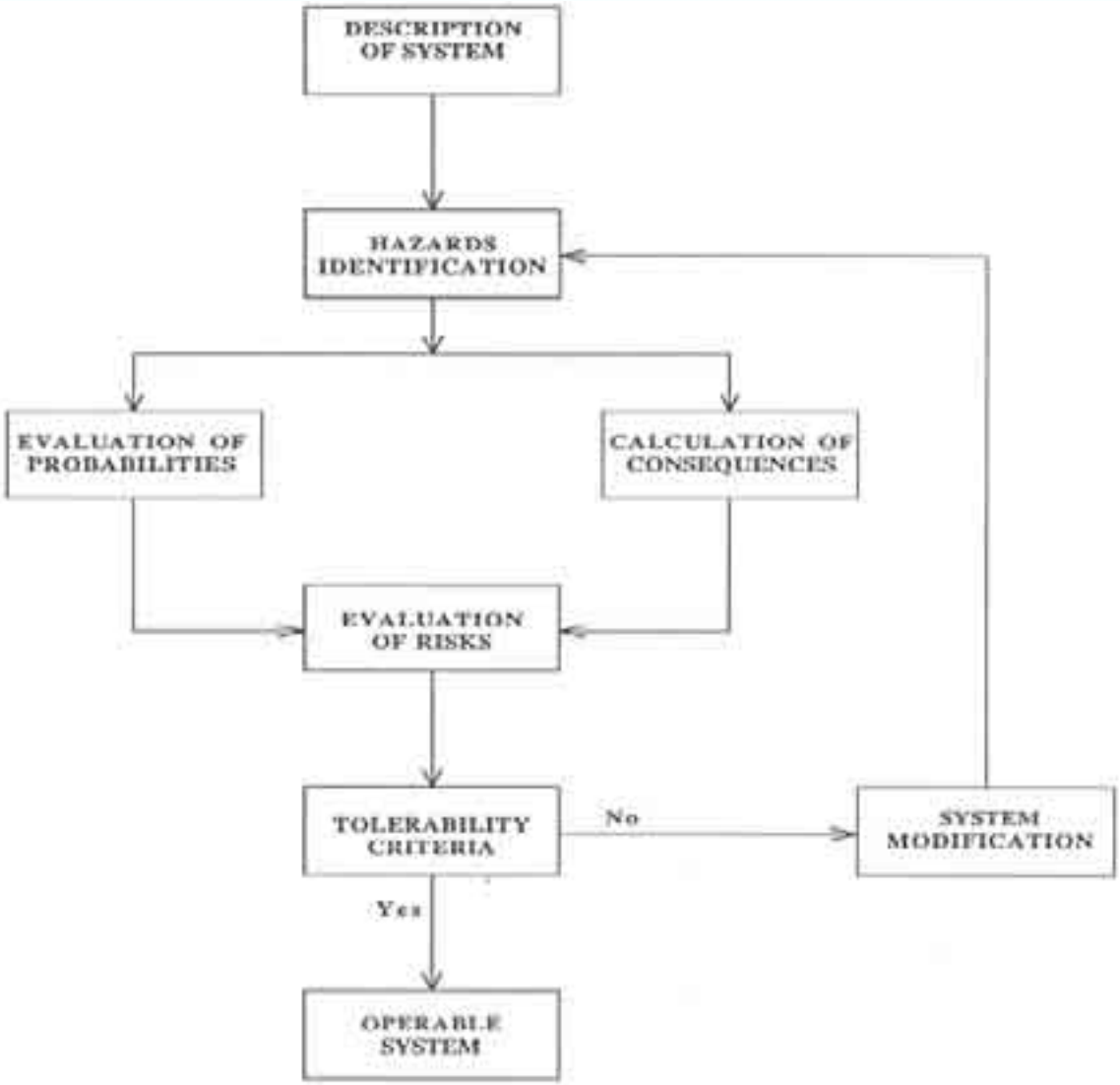
- MUST BE SUPPORTED BY THE HISTORICAL EXPERIENCE (REACTIVE APPROACH)

- IS BASED ON ANALYTICAL TECHNIQUES:

  - QUALITATIVE
    - HAZARDS IDENTIFICATION
    - SELECTION OF THE SIGNIFICANT EVENTS
    - MODELLING OF THE ACCIDENTAL BEHAVIOUR OF THE PLANT (ACCIDENTAL SEQUENCES)
    - MODELLING OF THE ACCIDENTAL BEHAVIOUR OF THE PLANT/ENVIRONMENT SYSTEM (ACCIDENTAL SCENARIOS)

  - QUANTITATIVE
    - EVALUATION OF THE LIKELIHOOD (PROBABILITY) OF ACCIDENTAL EVENTS
    - EVALUATION OF THE LIKELIHOOD (PROBABILITY) OF ACCIDENTAL SCENARIOS
    - CALCULATION OF ACCIDENTAL CONSEQUENCES
    - RISK EVALUATION

- GIVES EXPLICIT INDICATION OF THE POSSIBLE MEASURES OF PREVENTION AND PROTECTION.



THE PREDICTIVE APPROACH IN RISK ASSESSMENT

- LIMITATIONS DUE TO:
  - UNCERTAINTIES
  - RISOURCES

- BECAUSE OF UNCERTAINTIES, NEED TO MAKE AN EXTENSIVE USE OF "ENGINEERING JUDGMENT", MAINLY FOR:
  - SELECTION OF BASIS
  - SOURCE TERMS
  - IDENTIFICATION OF UNCERTAINTIES
  - CREDIBILITY OF RESULTS

- TO KEEP THE NECESSARY RESOURCES TO AN ACCEPTABLE LEVEL, NEED OF A GRADUAL AND FLEXIBLE APPROACH:

  - ADEQUATE SELECTION OF THE PROCEDURES

  - SEQUENCE OF LEVELS INCREASING IN DETAIL AND/OR EXTENSION

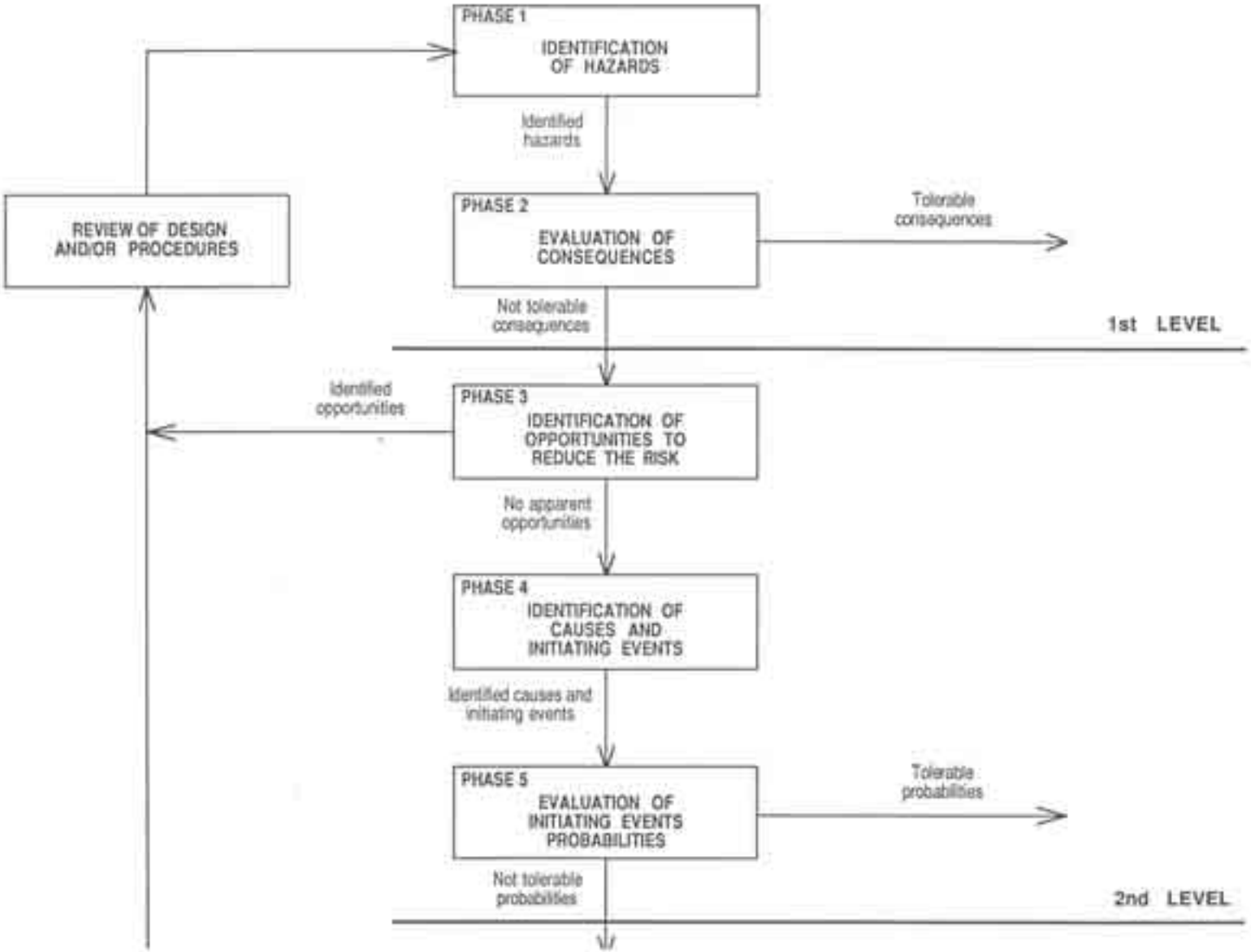
  - CONTINUATION OF THE ANALYSIS AT A HIGHER LEVEL ONLY WHERE AND WHEN SUITABLE (HIGH RISKS, COMPLEX PLANTS, NEW PROCESSES, ETC.)

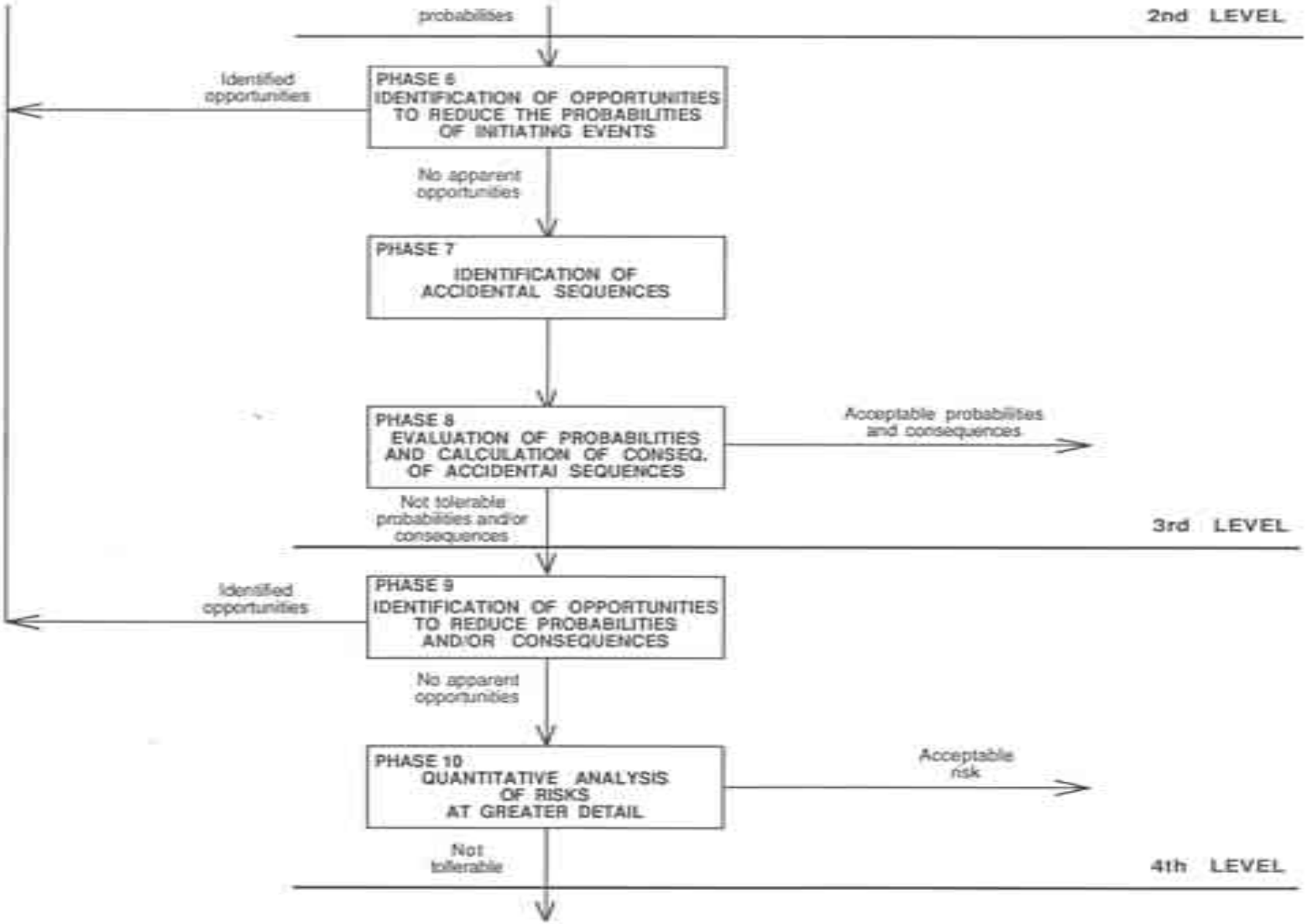
A POSSIBLE WAY TO DIVIDE
THE PROCESS OF RISK ASSESSMENT
INTO SUCCESSIVE PHASES IS REPRESENTED
BY THE SCHEME SUGGESTED BY AIChE.

10 SUCCESSIVE PHASES, RELATED TO
4 DIFFERENT LEVELS OF DETAIL.

AT THE END OF EACH ONE OF THESE
4 LEVELS, THE POSSIBILITY IS GIVEN
TO INTERRUPT THE PROCESS IN CASE
AN ACCEPTABILITY JUDGMENT
MAY ALREADY BE GIVEN.

AT ANY LEVEL, THE PROCESS MAY ALSO
BE CONTINUED FOR SOME PART ONLY
OF THE WHOLE PLANT (e.g. SOME UNIT
OR SYSTEM OR ASPECT):
POSSIBILITY OF SUCCESSIVE ABRIDGMENTS
TO LIMIT THE APPLICATION OF THE MOST
COMPLEX AND ONEROUS METHODOLOGIES.


PHASE 1
IDENTIFICATION OF HAZARDS
Identified hazards
PHASE 2
EVALUATION OF CONSEQUENCES
Tolerable consequences
Not tolerable consequences
1st LEVEL
REVIEW OF DESIGN AND/OR PROCEDURES
Identified opportunities
PHASE 3
IDENTIFICATION OF OPPORTUNITIES TO REDUCE THE RISK
No apparent opportunities
PHASE 4
IDENTIFICATION OF CAUSES AND INITIATING EVENTS
Identified causes and initiating events
PHASE 5
EVALUATION OF INITIATING EVENTS PROBABILITIES
Tolerable probabilities
Not tolerable probabilities
2nd LEVEL


probabilities
2nd LEVEL
Identified opportunities
PHASE 6
IDENTIFICATION OF OPPORTUNITIES TO REDUCE THE PROBABILITIES OF INITIATING EVENTS
No apparent opportunities
PHASE 7
IDENTIFICATION OF ACCIDENTAL SEQUENCES
PHASE 8
EVALUATION OF PROBABILITIES AND CALCULATION OF CONSEQ. OF ACCIDENTAI SEQUENCES
Acceptable probabilities and consequences
Not tolerable probabilities and/or consequences
3rd LEVEL
Identified opportunities
PHASE 9
IDENTIFICATION OF OPPORTUNITIES TO REDUCE PROBABILITIES AND/OR CONSEQUENCES
No apparent opportunities
PHASE 10
QUANTITATIVE ANALYSIS OF RISKS AT GREATER DETAIL
Acceptable risk
Not tollerable
4th LEVEL

FOR INSTANCE, A COMPLETE REFINERY INCLUDES AN AVERAGE OF AT LEAST 100 - 120 P&I DIAGRAMS.

A FULL HAZOP (ONE OF THE MOST POWERFUL HAZARDS IDENTIFICATION TECHNIQUES) TAKES ABOUT ONE DAY AND A HALF PER P&I DIAGRAM WITH A TEAM OF A MINIMUM OF THREE HIGHLY QUALIFIED TECHNICIANS, POSSIBLY AT TOP LEVEL.

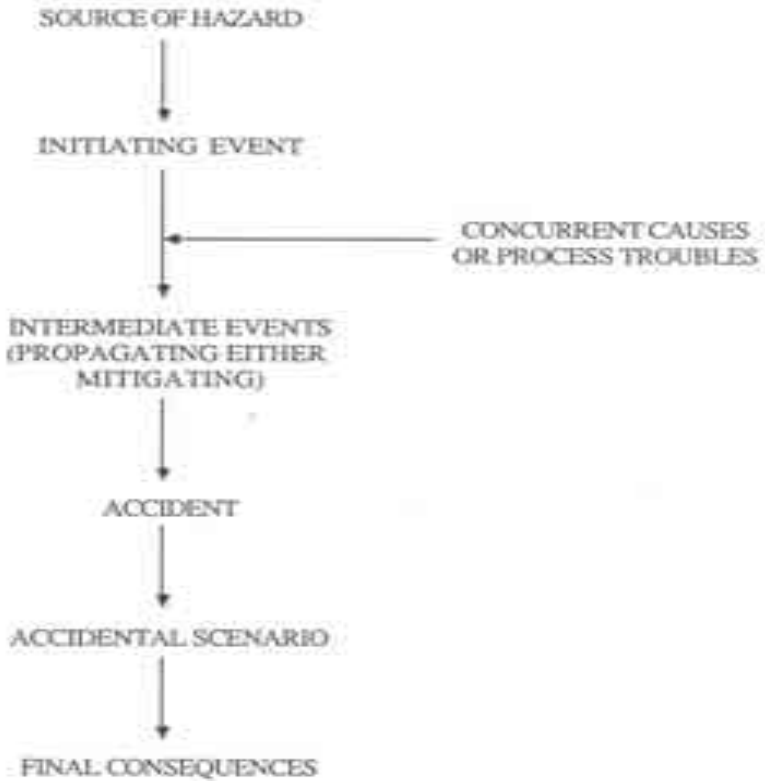
THE EXTENSIVE PERFORMANCE OF THE HAZOP ONLY ON THE WHOLE REFINERY WOULD REQUIRE 150 - 180 WORKING DAYS, CORRESPONDING TO ABOUT ONE YEAR AS DURATION AND 500 MAN/DAYS.

CORRESPONDINGLY THE COST WOULD BE IN THE ORDER OF 400,000 U.S.$.

THIS SAME MONEY COULD BE MUCH BETTER EMPLOYED BY A MORE ADEQUATE USE OF ANALYTICAL TECHNIQUES, AND ALLOCATING THE CORRESPONDENT FINANCIAL RESOURCE TO THE VERY INTERVENTS ON PLANT FOR PREVENTION OR PROTECTION.

THE OPPORTUNITY TO REDUCE THE RISK MAY BE GIVEN BY ANY ONE OF THE ELEMENTS CONTRIBUTING TO THE ACCIDENT.

THEREFORE IT IS VERY IMPORTANT THE KNOWLEDGE OF THE STRUCTURE OF AN ACCIDENT AND ITS SEQUENTIAL CHARACTER.



OPPORTUNITIES OF RISK REDUCTION

EACH ELEMENT OF
THE ACCIDENTAL SEQUENCE IS
SUSCEPTIBLE TO CONTROL THE RISK BY:

- PREVENTING THE SEQUENCE TO START AT ALL
- INTERRUPTING THE SEQUENCE AT AN INTERMEDIATE LEVEL

PREVENTION

- ADRESSING ITS DEVELOPMENT IN A LESS UNFAVOURABLE DIRECTION
- MITIGATING THE FINAL CONSEQUENCES

PROTECTION

CORRESPONDINGLY, THE POSSIBLE INTERVENTS MAY BE CLASSIFIED ACCORDING THEIR AIM:

- **REDUCTION OF THE PROBABILITY OF INITIATING EVENTS**

  IMPROVEMENT OF THE COMPONENT QUALITY
  REDUNDANCY OF INSTRUMENTATION
  IMPROVEMENT IN TRAINING
  ETC.

- **REDUCTION OF THE POSSIBILITY OF PROPAGATION THROUGH THE SEQUENCE**

  SAFETY VALVES
  RUPTURE DISCS
  ISOLATION SYSTEMS
  DEPRESSURING OR BLOW DOWN SYSTEMS
  EXPLOSION SUPRESSION
  BLANKETING
  SCRUBBING SYSTEMS
  ETC.

- **ACTIVE PROTECTION**

  FIREFIGHTING FACILITIES
  WATER CURTAINS
  STEAM CURTAINS
  EQUIPMENT COOLING SYSTEMS
  ANTIEVAPORATING FOAM BLANKETS
  ETC.

- **PASSIVE PROTECTION**

  SEPARATION DISTANCES
  EXPLOSION PROOFING
  BLASTPROOF BARRIERS
  HOLDING BASINS
  FIRE PROOFING
  ETC.

- **EMERGENCY MANAGEMENT**

  PLANNING
  REHEARSALS
  INFORMATION TO POPULATION
  ETC.

MAIN FACTORS INFLUENCING THE LEVEL OF RISK

1. SEPARATION DISTANCES BETWEEN PLANTS AND POPULATION
2. DENSITY OF POPULATION AND PRESENCE OF HIGHLY VULNERABLE TARGETS (SCHOOLS, HOSPITALS, ETC.)
3. HOLD-UP OF HAZARDOUS MATERIALS AND STORAGE CONDITIONS
4. PROCESS WORKING CONDITIONS
5. PIPING SIZE
6. SAFETY SYSTEMS - ACTIVE OR PASSIVE (HOLDING BASINS, REMOTE ISOLATION, PROCESS CONTROL AND BLOCK, ETC.)
7. RISK MANAGEMENT PROVISIONS (TRAINING, SUPERVISION, PROCEDURES, HOUSEKEEPING, INSPECTIONS, ETC.)

8. PHYSICAL/CHEMICAL PROPERTIES OF SUBSTANCES (FLAMMABILITY, TOXICITY, VOLATILITY, ETC.)

9. AVERAGE METEOROLOGICAL CONDITIONS (CLASS OF STABILITY, WIND DIRECTION AND SPEED, ETC.)

10. TOPOGRAPHY (PRESENCE OF HILLS, VALLEYS, VEGETATION, BUILDINGS, ETC.)

11. PARTICULAR MITIGATING/AGGRAVATING FACTORS (VENTILATION IN BUILDINGS, INFORMATION TO THE POPULATION, EMERGENCY PLANNING, MOBILITY AND SITE ACCESSIBILITY, ETC.)

MAIN SOURCES OF UNCERTAINTIES IN THE ANALYTICAL APPROACH

1. SELECTION OF THE REPRESENTATIVE SET OF ACCIDENTAL SCENARIOS
2. RELEASED QUANTITIES DUE TO THE SUDDEN COLLAPSE OF STORAGE TANKS
3. SEMI-CONTINUOUS RELEASES DUE TO MAJOR FAILURES OF VESSELS OR PIPING (LOCATION AND SIZE, ACTUAL PROCESS CONDITIONS)
4. DURATION OF RELEASE
5. PROBABILITY OF THE ACCIDENT
6. PROBABILITY OF THE ACCIDENTAL SCENARIO
7. SOURCE TERMS FOR THE EVALUATION OF CONSEQUENCES (INITIAL DILUTION FACTOR, COMBUSTION EFFICIENCY,ETC.)

8. LIQUID ENTRAINMENT AND AEROSOL FORMATION IN HIGH PRESSURE RELEASES

9. MODELS FOR THE EVALUATION OF CONSEQUENCES (HEAVY CLOUDS, JET DISPERSION, EXPLODING MASS, ETC.)

10. TOXICITY DATA

11. MITIGATION DUE TO AMBIENT FACTORS OR POPULATION BEHAVIOUR

BECAUSE OF ALL THESE UNCERTAINTIES,
A GREAT CARE IS NEEDED IN THE
CORRECT INTERPRETATION OF RESULTS.

IN ANY CASE,
A "CERTAINLY CONSERVATIVE RESULT"
MAY NOT BE ALWAYS ACCEPTABLE
(IT MAY LEAD TO SOLUTIONS NOT OPTIMAL
FROM SOME POINT OF VIEW:
TECHNICAL, ECONOMICAL OR SOCIAL).

VERY OFTEN IT BECOMES NECESSARY
TO PERFORM A "BEST ESTIMATE".

SO, A GREAT EXPERIENCE IS ESSENTIAL
(A GENERAL ENGINEERING EXPERIENCE
AND A VERY SPECIFIC ONE ON THE
KIND OF PLANT UNDER EXAMINATION).

THE FINAL RESULTS OF THE ANALYSIS
MUST BE SUBJECTED TO A GENERAL
AND CRITICAL "CREDIBILITY JUDGMENT"

CRITERIA FOR THE SELECTION OF A METHODOLOGY

TWO KIND OF FACTORS HAVE TO BE TAKEN INTO CONSIDERATION:

- INTRINSIC ATTRIBUTES CHARACTERIZING THE METHODOLOGY
- CONDITIONS CHARACTERIZING THE SCOPE AND THE CONTEXT OF THE APPLICATION (EXTERNAL FACTORS)

INTRINSIC ATTRIBUTES

1. OBJECTIVE OF THE METHODOLOGY (HAZARDS IDENTIFICATION, RISK RANKING, ETC.)

2. RANGE OF APPLICABILITY (TO A DETERMINATE STAGE OF DESIGN DEVELOPMENT, TO A PARTICULAR TYPE OF INDUSTRY, ETC.)

3. FORM OF THE RESULTS (LIST OF ITEMS, CATEGORIES OF RISK, RANGE OF ACCIDENTAL EFFECTS, ETC.)

4. NATURE OF THE RESULTS (QUALI-TATIVE, QUANTITATIVE)

5. DATA AND SOURCE TERMS REQUIRED (PROCESS FLOW SHEETS, LAY-OUT, P&I DIAGRAMS, ETC.)

6. HUMAN RESOURCES REQUIRED (QUALIFICATION, SKILLFULNESS, SPECIFIC EXPERIENCES, ETC.)

EXTERNAL FACTORS

1. SCOPE OF THE RISK ASSESSMENT

- PRELIMINARY CONCEPTION OF A PROJECT
- SELECTION AMONG DIFFERENT TECHNOLOGIES
- SEARCH FOR TECHNICAL SOLUTIONS
- SEARCH FOR MANAGERIAL/ADIMISTRATIVE SOLUTIONS
- GLOBAL ANALYSIS OF AN AREA
- ETC.

2. DEVELOPMENT STAGE OF PROCESS/PLANT

- SCREENING FOR A FEASIBILITY STUDY OR FOR EARLY STAGES OF DESIGN
- GREATER DETAIL FOR ADVANCED STAGES OF A DESIGN

3. POTENTIAL MAGNITUDE OF ACCIDENTAL CONSEQUENCES

- SCREENING BASED ON THE "WORST CASE"
- DEEPENING COMMENSURATE WITH THE ACTUAL LEVEL OF RISK AND CONCERNING THE MOST HAZARDOUS SITUATIONS ONLY

4. COMPLEXITY OF THE PROCESS/PLANT

- SCREENING FOR FLEXIBILITY IN APPLYING METHODOLOGIES
- GREATER DETAIL IN PRESENCE OF EXTENDED OR COMPLEX SYSTEMS OF CONTROL/PROTECTION/MITIGATION
- SYSTEMATIC/COMPONENTISTIC NATURE

5. ACTUAL SKILLFULNESS WITH THE METHODOLOGY

- ACTUAL SPECIFIC EXPERIENCE IN THE APPLICATION IT WILL BE MUCH BETTER TO SELECT A LESS SOPHISTICATED BUT WELL UNDERSTOOD METHODOLOGY RATHER THAN A VERY POWERFUL ONE BUT NOT FULLY KNOWN

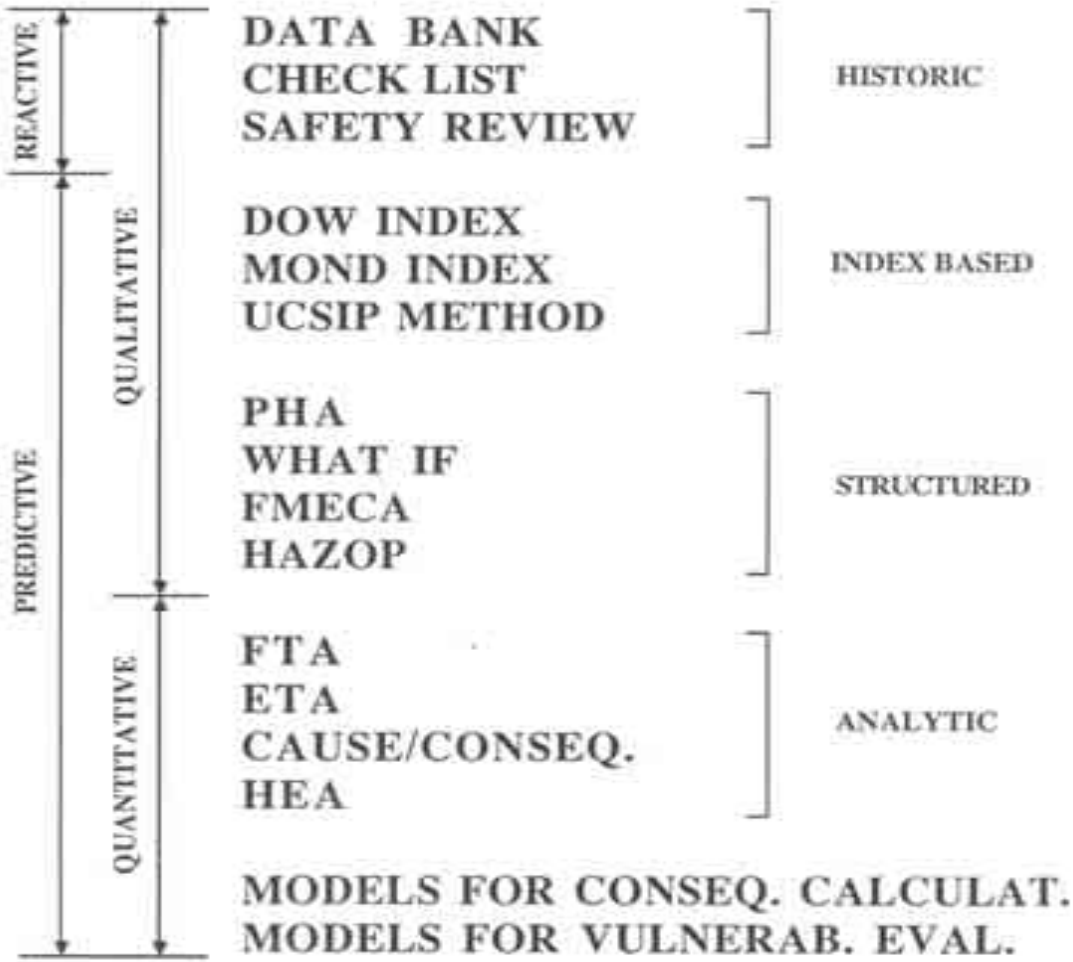
6. AVAILABILITY OF DATA AND INFORMATIONS

- SCARCE DOCUMENTATION AVAILABLE IN EARLY STAGES OF DESIGN WILL NOT LET COMPLEX METHODOLOGIES TO BE USED
- IBID FOR OLD PLANTS, WHERE GENERALLY DOCUMENTATION IS SCARCE OR NOT UPDATED

7. AVAILABILITY OF RESOURCES

- LIMITATIONS IN TIME/HUMAN/ECONOMIC RESOURCES MAY NOT LET COMPLEX METHODOLOGIES TO BE APPLIED

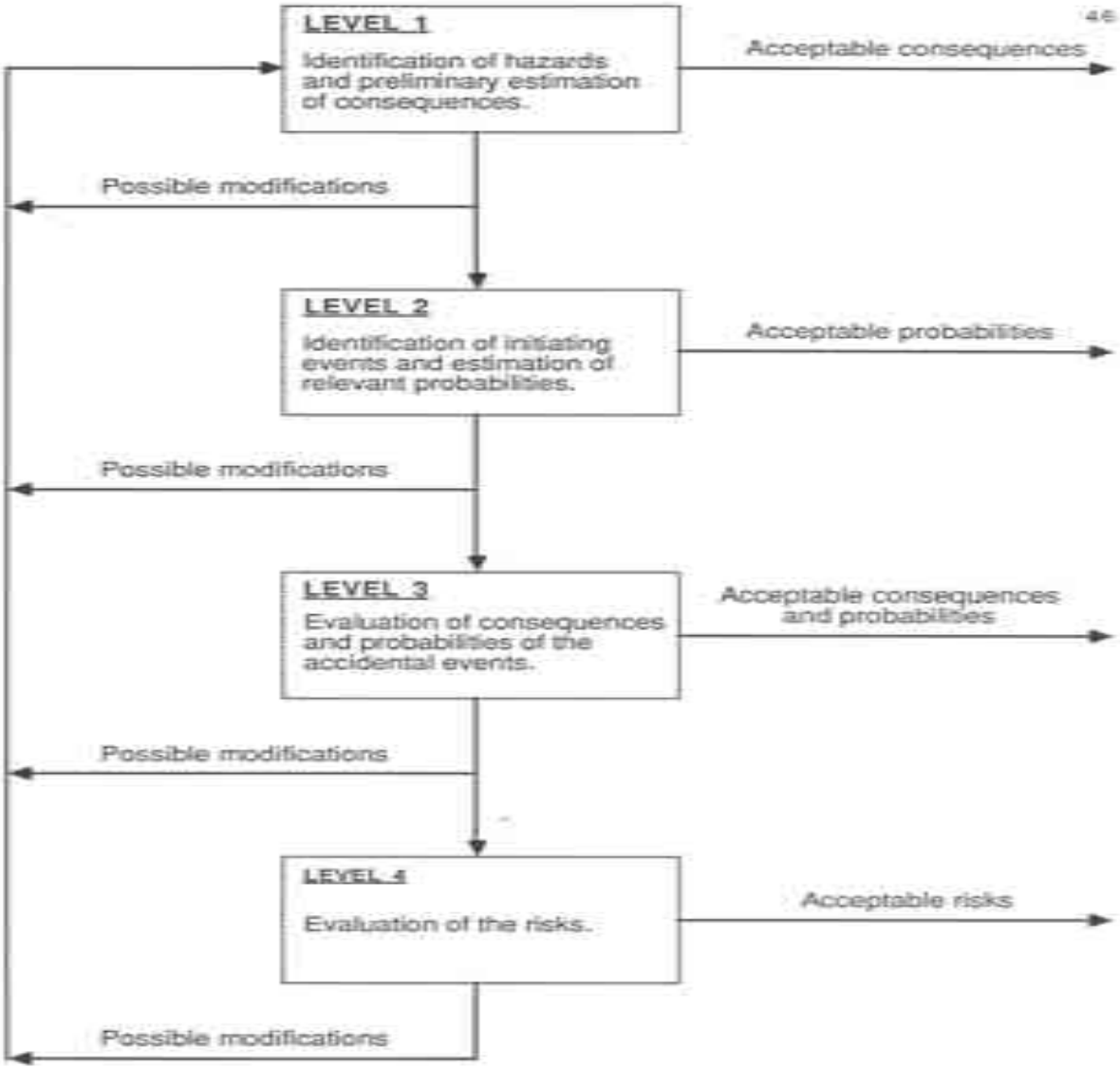
MOST COMMON ASSESSMENT METHODOLOGIES



SYNOPTIC TABLE OF THE MAIN QUALITATIVE METHODOLOGIES

(follows . 2)

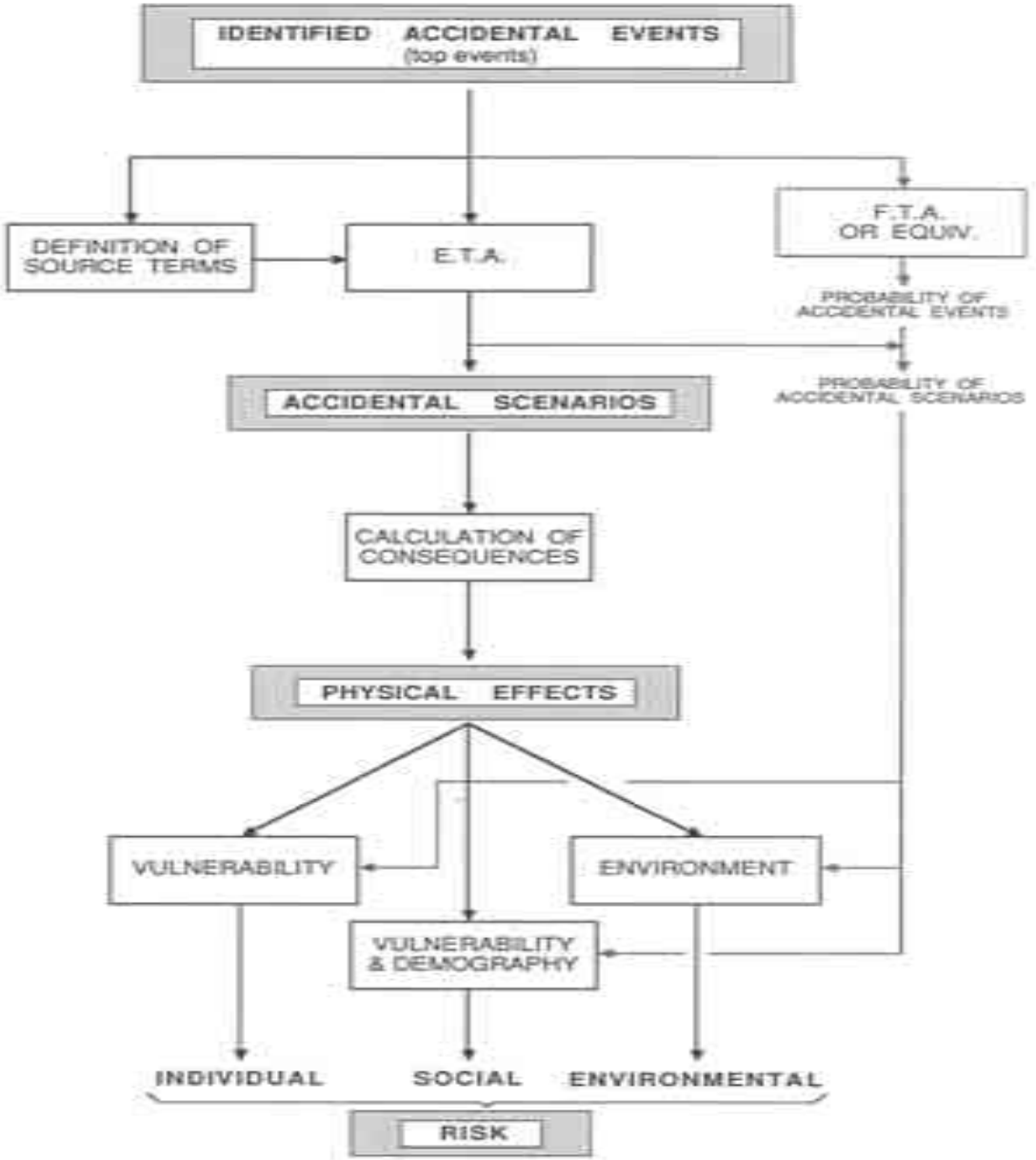
METHODOLOGY	CHARACTERISTICS	ADVANTAGES	DISADVANTAGES	USE IN PROCESS INDUSTRY	COMMENTS
Hazard and Operability Study (HAZOP)	Analyzes causes and effects of deviations in process parameters from normal operating conditions. The procedure, carried out by an articulated team of experts, consists in systematic application of key words item by item, line by line, parameter by parameter.	Like Safety Review, but ensures a much higher level of completeness. Provides useful source terms for the application of other methodologies.	Only an onerous application may ensure a level of completeness meaningfully higher than in other methodologies. Requires a great technical experience. Not completely adequate for identification of human errors.	Frequent	Very useful also for operability studies, in many cases will also have an economical pay-out. Efforts under way to create a computerized aid.
Failure Modes Effects and Criticality Analysis (FMECA)	Identifies systematically the different modes of failure item by item and analyzes possibly arising accidental sequences.	May be extremely rigorous and complete (componentistic aspects only). Provides useful source terms for application of other methodologies (FTA, ETA, etc.).	Extremely onerous if applied rigorously, in its less detailed version may be adequately replaced by other simpler methodologies (PHA, What if). Not able to identify causes other than componentistic.	Infrequent	Useful only where componentistic aspects are predominant (power stations, aeronautical industry, nuclear plants, pumping stations, etc.).



GRADUAL APPROACH IN THE APPLICATION OF HAZARDS EVALUATION TECHNIQUES.

LEVEL OF APPLICATION OF THE VARIOUS METHODOLOGIES

LEVEL	METHODOLOGIES TYPICALLY APPLIED
1	Data banks Check lists Safety reviews Dow Index Mond Index UCSIP Method (refineries only) Preliminary Hazard Analysis "What if " Hazard and Operability Study
2	Statistical Analysis "What if" Hazard and Operability Study Failure Mode, Effect and Criticality Analysis Fault Tree Analysis Human Error Analysis
3	Statistical Analysis UCSIP Method (refineries only) "What if" Fault Tree Analysis Event Tree Analysis Cause/consequences Analysis Human Error Analysis Models for consequences evaluation
4	Models for vulnerability evaluation Models for risk estimation


IDENTIFIED ACCIDENTAL EVENTS
(top events)
DEFINITION OF SOURCE TERMS
E.T.A.
F.T.A. OR EQUIV.
PROBABILITY OF ACCIDENTAL EVENTS
ACCIDENTAL SCENARIOS
PROBABILITY OF ACCIDENTAL SCENARIOS
CALCULATION OF CONSEQUENCES
PHYSICAL EFFECTS
VULNERABILITY
ENVIRONMENT
VULNERABILITY & DEMOGRAPHY
INDIVIDUAL
SOCIAL
ENVIRONMENTAL
RISK

USE OF RESULTS

EACH PHASE SHOWN IN THE PREVIOUS SLIDE PROVIDES A DETERMINATE TYPE OF RESULTS.

AREA OF INTEREST → TECHNICAL
AREA OF INTEREST → MANAGERIAL

TECHNICAL INTEREST

TYPE OF INFORMATION REQUIRED TO THE ASSESSMENT:

- IDENTIFICATION OF HAZARDS AND ACCIDENTAL SEQUENCES
- ESTIMATION OF EVENTS LIKELIHOOD
- EVALUATION OF CONSEQUENCES
- RANKING OF THE RISK GENERATED BY THE EVENTS
- TECHNICAL SUGGESTIONS FOR IMPROVEMENT

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POSSIBLE TYPE OF INTERVENTS FOR IMPROVEMENT:

- MODIFICATION OF DESIGN CRITERIA
- MODIFICATION OF PROCESS CONTROL BASIS
- MODIFICATION OF OPERATING CONDITIONS
- CHANGE OF PROCESS FLUIDS
- MODIFICATION OF LAY-OUT
- MODIFICATION OF OPERATING OR MAINTENANCE PROCEDURES

INTERVENTS MAY OBTAIN IMPROVEMENT (RISK MITIGATION) BY:

- ELIMINATION OF THE HAZARD SOURCE
- REDUCTION OF CONSEQUENCES (PROTECTION)
- REDUCTION OF PROBABILITIES (PREVENTION)

CAUTION !

THE HEEDLESS IMPLEMENTATION OF A MODIFICATION, ORIGINALLY INTENDED AS A REDUCTION OF SOME OF THE SOURCES OF RISK, MAY ON THE CONTRARY GIVE RISE TO NEW, GREATER AND UNEXPECTED HAZARDS.

FOR INSTANCE:

- INADEQUACY OF A BLOW-DOWN HEADER TO CONVEY EMERGENCY DISCHARGES DUE TO THE CONVEYING OF A NEW PSV DISCHARGE, ORIGINALLY TO ATMOSPHERE.
- INADEQUACY OF AN EMERGENCY ELECTRIC GENERATOR TO COMPLY WITH THE REQUIREMENTS DUE TO THE CONNECTION OF A NEW CRITICAL USER TO THE VITAL BUS-BAR

ANY MODIFICATION TO A PLANT REQUIRES A CAREFULL EXAMINATION OF ALL THE POSSIBLE DIRECT AND INDIRECT CONSEQUENCES.

THE ACCIDENT AT FLIXBOROUGH HAS BEEN CAUSED BECAUSE THIS SIMPLE AND OBVIOUS RULE HAS BEEN DISREGARDED !

MANAGERIAL OR ADMINISTRATIVE INTEREST

TYPE OF INFORMATION REQUIRED TO THE ASSESSMENT:

- IDENTIFICATION OF HAZARDS
- ESTIMATION OF EVENTS LIKELIHOOD AND CONSEQUENCES
- VERIFICATION OF THE RESPECT OF REGULATORY REQUIREMENTS
- RANKING OF THE RISK GENERATED BY THE EVENTS
- SUGGESTIONS FOR IMPROVEMENT ON MANAGERIAL BASIS

POSSIBLE TYPE OF INTERVENTS FOR IMPROVEMENT:

- MODIFICATION OF BASIC TECHNOLOGY
- CONVERSION TO OTHER TYPE OF MANUFACTURING
- DELOCALIZATION OF THE PLANT OR ITS SHUT DOWN
- LIMITATION OR DELOCALIZATION OF INHABITED AREAS
- WORKS FOR CONTAINMENT OR PROTECTION (POSSIBLY EXTERNAL TO THE PLANT LIMITS)
- INTERNAL AND EXTERNAL EMERGENCY PLAN
- INFORMATION TO THE POPULATION
- TRAINING OF PERSONNEL