M. Tech. DEGREE
INDUSTRIAL SAFETY ENGINEERING

SYLLABUS
FOR
CREDIT BASED CURRICULUM
(2009 -2010)

DEPARTMENT OF MECHANICAL ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY
TIRUCHIRAPPALLI – 620 015, INDIA.
**M.Tech. - INDUSTRIAL SAFETY ENGINEERING**

The total credits required for completing the M.Tech. Programme is 63

### SEMESTER I

<table>
<thead>
<tr>
<th>Code</th>
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<tbody>
<tr>
<td>MA 611</td>
<td>Probability and Statistics</td>
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### SEMESTER III

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**Total Credits** 63
# LIST OF ELECTIVES

## SEMESTER I

**ELECTIVE – I**

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## SEMESTER II

**ELECTIVE - II, III & IV**

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MA 611 - PROBABILITY AND STATISTICS (3 – 1 – 0) 4

Random variable – Two dimensional random variables – Standard probability distributions – Binomial, Poisson and Normal distributions - Moment generating function.

Special distributions – Uniform, Geometric, Exponential, Gamma, Weibull and Beta distributions – Mean, Variance, Raw moments from moment generating functions of respective distributions.

Sampling distributions – Confidence interval estimation of population parameters – Testing of hypotheses – Large sample tests for mean and proportion – t-test, F-test and Chi-square test.

Curve fitting - Method of least squares - Regression and correlation – Rank correlation – Multiple and partial correlation – Analysis of variance - One way and two way classifications – Time series analysis.


References:
1. BOWKER and LIBERMAN, Engineering Statistics, Prentice-Hall.

ME 653 – SAFETY MANAGEMENT (3 – 0 – 0) 3

CONCEPTS
Evolution of modern safety concept- Safety policy - Safety Organization - line and staff functions for safety- Safety Committee- budgeting for safety.

TECHNIQUES
Incident Recall Technique (IRT), disaster control, Job Safety Analysis (JSA), safety survey, safety inspection, safety sampling, Safety Audit.

ACCIDENT INVESTIGATION AND REPORTING
Concept of an accident, reportable and non reportable accidents, unsafe act and condition – principles of accident prevention, Supervisory role- Role of safety committee - Accident causation models - Cost of accident. Overall accident investigation process - Response to accidents, India reporting requirement, Planning document, Planning matrix, Investigators Kit, functions of investigator, four types of evidences, Records of accidents, accident reports- Class exercise with case study.
SAFETY PERFORMANCE MONITORING
permanent total disabilities, permanent partial disabilities, temporary total disabilities -
Calculation of accident indices, frequency rate, severity rate, frequency severity incidence,
incident rate, accident rate, safety “t” score, safety activity rate – problems.

SAFETY EDUCATION AND TRAINING
Importance of training-identification of training needs-training methods – programme,
seminars, conferences, competitions – method of promoting safe practice - motivation –
communication - role of government agencies and private consulting agencies in safety
training – creating awareness, awards, celebrations, safety posters, safety displays, safety
pledge, safety incentive scheme, safety campaign – Domestic Safety and Training.

References

ME 655 – OCCUPATIONAL HEALTH AND HYGIENE (3 – 0 – 3) 4

PHYSICAL HAZARDS
Noise, compensation aspects, noise exposure regulation, properties of sound, occupational
damage, risk factors, sound measuring instruments, octave band analyzer, noise networks,
noise surveys, noise control program, industrial audiometry, hearing conservation programs-
vibration, types, effects, instruments, surveying procedure, permissible exposure limit.

Ionizing radiation, types, effects, monitoring instruments, control programs, OSHA standard-
non-ionizing radiations, effects, types, radar hazards, microwaves and radio-waves, lasers,
TLV- cold environments, hypothermia, wind chill index, control measures- hot environments,
thermal comfort, heat stress indices, acclimatization, estimation and control

CHEMICAL HAZARDS
Recognition of chemical hazards-dust, fumes, mist, vapour, fog, gases, types, concentration,
Exposure vs. dose, TLV - Methods of Evaluation, process or operation description, Field
Survey, Sampling methodology, Industrial Hygiene calculations, Comparison with OSHAS
Standard.

Air Sampling instruments, Types, Measurement Procedures, Instruments Procedures, Gas and
Vapour monitors, dust sample collection devices, personal sampling

Methods of Control - Engineering Control, Design maintenance considerations, design
specifications - General Control Methods - training and education

BIOLOGICAL AND ERGONOMICAL HAZARDS
Classification of Biohazardous agents –bacterial agents, rickettsial and chlamydial agents,
viral agents, fungal, parasitic agents, infectious diseases - Biohazard control program,
employee health program-laboratory safety program-animal care and handling-biological
safety cabinets - building design.
Work Related Musculoskeletal Disorders – carpal tunnel syndrome CTS- Tendon pain disorders of the neck back injuries.

**OCCUPATIONAL HEALTH AND TOXICOLOGY**

Concept and spectrum of health - functional units and activities of occupational health services, pre-employment and post-employment medical examinations - occupational related diseases, levels of prevention of diseases, notifiable occupational diseases such as silicosis, asbestosis, pneumoconiosis, siderosis, anthracosis, aluminosis and anthrax, lead-nickel, chromium and manganese toxicity, gas poisoning (such as CO, ammonia, coal and dust etc) their effects and prevention – cardio pulmonary resuscitation, audiometric tests, eye tests, vital function tests.

Industrial toxicology, local, systemic and chronic effects, temporary and cumulative effects, carcinogens entry into human systems

**OCCUPATIONAL PHYSIOLOGY**


**References**


**ME 657 – SAFETY IN ENGINEERING INDUSTRY (3 – 0 – 0) 3**

**SAFETY IN METAL WORKING MACHINERY AND WOOD WORKING MACHINES**

General safety rules, principles, maintenance, Inspections of turning machines, boring machines, milling machine, planning machine and grinding machines, CNC machines,

Wood working machinery, types, safety principles, electrical guards, work area, material handling, inspection, standards and codes- saws, types, hazards.

**PRINCIPLES OF MACHINE GUARDING**

Guarding during maintenance, Zero Mechanical State (ZMS), Definition, Policy for ZMS – guarding of hazards - point of operation protective devices, machine guarding, types, fixed guard, interlock guard, automatic guard, trip guard, electron eye, positional control guard, fixed guard fencing- guard construction- guard opening.

SAFETY IN WELDING AND GAS CUTTING
Gas welding and oxygen cutting, resistances welding, arc welding and cutting, common hazards, personal protective equipment, training, safety precautions in brazing, soldering and metalizing – explosive welding, selection, care and maintenance of the associated equipment and instruments – safety in generation, distribution and handling of industrial gases-colour coding – flashback arrestor – leak detection-pipe line safety-storage and handling of gas cylinders.

SAFETY IN COLD FORMING AND HOT WORKING OF METALS
Cold working, power presses, point of operation safe guarding, auxiliary mechanisms, feeding and cutting mechanism, hand or foot-operated presses, power press electric controls, power press set up and die removal, inspection and maintenance-metal sheers-press brakes.

Hot working safety in forging, hot rolling mill operation, safe guards in hot rolling mills – hot bending of pipes, hazards and control measures.

Safety in gas furnace operation, cupola, crucibles, ovens, foundry health hazards, work environment, material handling in foundries, foundry production cleaning and finishing foundry processes.

SAFETY IN FINISHING, INSPECTION AND TESTING
Heat treatment operations, electro plating, paint shops, sand and shot blasting, safety in inspection and testing, dynamic balancing, hydro testing, valves, boiler drums and headers, pressure vessels, air leak test, steam testing, safety in radiography, personal monitoring devices, radiation hazards, engineering and administrative controls, Indian Boilers Regulation.

References
5. Indian Boiler acts and Regulations, Government of India.

ME 659 – REGULATIONS FOR HEALTH, SAFETY AND ENVIRONMENT
(3 – 0 – 0) 3

Factories act and rules - Workmen compensation act.
Indian explosive act - Gas cylinder rules - SMPV Act - Indian petroleum act and rules.
Environmental pollution act
Manufacture, Storage and Import of Hazardous Chemical rules 1989
Indian Electricity act and rules.
Overview of OHSAS 18000 and ISO 14000

References

Department of Mechanical Engineering, National Institute of Technology, Tiruchirappalli – 620 015.
7. ISO 9000 to OHSAS 18001, Dr. K.C. Arora, S.K. Kataria & Sons, Delhi

SEMESTER – II

ME 652 – COMPUTER AIDED RISK ANALYSIS(3 – 1 – 0) 4

HAZARD, RISK ISSUES AND HAZARD ASSESSMENT
Introduction, hazard, hazard monitoring-risk issue - Hazard assessment, procedure, methodology; safety audit, checklist analysis, what-if analysis, safety review, preliminary hazard analysis (PHA), hazard operability studies (HAZOP)

INSTRUMENTATION
Applications of Advanced Equipments and Instruments, Thermo Calorimetry, Differential Scanning Calorimeter (DSC), Thermo Gravimetric Analyzer (TGA), Accelerated Rate Calorimeter (ARC), Principles of operations, Controlling parameters, Applications, advantages.

Explosive Testing, Deflagration Test, Detonation Test, Ignition Test, Minimum ignition energy Test, Sensitiveness Test, Impact Sensitiveness Test (BAM) and Friction Sensitiveness Test (BAM), Shock Sensitiveness Test, Card Gap Test.

RISK ANALYSIS QUANTIFICATION AND Softwares
Fault Tree Analysis & Event Tree Analysis, Logic symbols, methodology, minimal cut set ranking - fire explosion and toxicity index(FETI), various indices - Hazard analysis(HAZAN)- Failure Mode and Effect Analysis (FMEA) - Basic concepts of Software on Risk analysis, CISCON, FETI, ALOHA

CONSEQUENCES ANALYSIS
Logics of consequences analysis- Estimation- Hazard identification based on the properties of chemicals- Chemical inventory analysis- identification of hazardous processes- Estimation of source term, Gas or vapour release, liquid release, two phase release- Heat radiation effects, BLEVE, Pool fires and Jet fire- Gas/vapour dispersion- Explosion, UVCE and Flash fire, Explosion effects and confined explosion- Toxic effects- Plotting the damage distances on plot plant/layout.

References

Department of Mechanical Engineering, National Institute of Technology, Tiruchirappalli – 620 015.
3. Hazop and Hazon, by Trevor A Klett, Institute of Chemical Engineering.
4. Quantitative Risk assessment in Chemical Industries, Institute of Chemical Industries, Centre for Chemical process safety.

ME 654 – SAFETY IN CHEMICAL INDUSTRIES (3 – 0 – 0) 3

SAFETY IN PROCESS DESIGN AND PRESSURE SYSTEM DESIGN
Design process, conceptual design and detail design, assessment, inherently safer design-chemical reactor, types, batch reactors, reaction hazard evaluation, assessment, reactor safety, operating conditions, unit operations and equipments, utilities.

Pressure system, pressure vessel design, standards and codes- pipe works and valves- heat exchangers- process machinery- over pressure protection, pressure relief devices and design, fire relief, vacuum and thermal relief, special situations, disposal- flare and vent systems-failures in pressure system.

PLANT COMMISSIONING AND INSPECTION
Commissioning phases and organization, pre-commissioning documents, process commissioning, commissioning problems, post commissioning documentation

Plant inspection, pressure vessel, pressure piping system, non destructive testing, pressure testing, leak testing and monitoring- plant monitoring, performance monitoring, condition, vibration, corrosion, acoustic emission-pipe line inspection.

PLANT MAINTENANCE, MODIFICATION AND EMERGENCY PLANNING
Management of maintenance, hazards- preparation for maintenance, isolation, purging, cleaning, confined spaces, permit system- maintenance equipment- hot works- tank cleaning, repair and demolition- online repairs- maintenance of protective devices- modification of plant, problems- controls of modifications.

Emergency planning, disaster planning, onsite emergency- offsite emergency, APELL

STORAGES AND TRANSPORTATION
General consideration, petroleum product storages, storage tanks and vessel- storages layout-segregation, separating distance, secondary containment- venting and relief, atmospheric vent, pressure, vacuum valves, flame arrestors, fire relief- fire prevention and protection-LPG storages, pressure storages, layout, instrumentation, vapourizer, refrigerated storages-LNG storages, hydrogen storages, toxic storages, chlorine storages, ammonia storages, other chemical storages- underground storages- loading and unloading facilities- drum and cylinder storage- ware house, storage hazard assessment of LPG and LNG Hazards during transportation – pipeline transport

PLANT OPERATIONS
Operating discipline, operating procedure and inspection, format, emergency procedures-hand over and permit system- start up and shut down operation, refinery units- operation of fired heaters, driers, storage- operating activities and hazards- trip systems- exposure of personnel.
Specific safety consideration for Cement, paper, pharmaceutical, petroleum, petro-chemical, rubber, fertilizer and distilleries.

**Text Book**

**References**

**ME 656 – FIRE ENGINEERING AND EXPLOSION CONTROL (3 – 0 – 0) 3**

Fire chemistry – Dynamics of fire behavior – Fire properties of solid, liquid and gas – Fire spread – Toxicity of products of combustion

Industrial fire protection systems – Sprinkler – Hydrants- Stand pipe- Special fire suppression system like deluge and emulsifier.

Building evaluation for fire safety – Fire load –Fire resistance materials and fire testing – Structural Fire protection – Exits and egress.

Explosion protection systems – Explosion parameters – Explosion suppression system based on CO₂ and Halon – Hazards in L.P.G handling.


**References**

**ME 658 – INDUSTRIAL SAFETY LABORATORY (3 – 0 – 0) 3**

1. **NOISE LEVEL MEASUREMENT AND ANALYSIS**

2. **VIBRATION MEASUREMENT AND ANALYSIS**
   Measurement of whole body vibration for various acceleration: *Instrument – vibration simulator and vibration analyzer*
3. **FRICITION SENSITIVITY TEST**
Measurement of friction sensitivity for unstable materials: *Instrument – BAM friction tester*

4. **IMPACT SENSITIVITY TEST**
Measurement of impact sensitivity for unstable materials: *Instrument – BAM fall hammer*

5. **THERMAL REACTIVITY TEST**
Measurement of thermal reactivity for unstable materials: *Instrument – DSC/TGA*

6. **EXHAUST GAS MEASUREMENT AND ANALYSIS**
Measurement of Exhaust gas measurement of IC engines: *Instrument – Gas analyzer*

7. **BREATHING ZONE CONCENTRATION**
Measurement of breathing zone concentration of dust and fumes: *Instrument – personal air sampler*

8. **AMBIENT AIR MONITORING**
Measurement of respirable and non-respirable dust in the ambient air: *Instrument – High volume sampler*

9. **CONSEQUENCE ANALYSIS**
Soft computing skills on developing effects of fire & explosion and dispersion: *Software – PHAST 1 and ALOHA*

10. **STUDY OF PERSONAL PROTECTIVE EQUIPMENT:**
Safety helmet, belt, hand gloves, goggles, safety shoe, gum boots, ankle shoes, face shield, nose mask, ear plug, ear muff, apron and leg guard.

11. **STUDY OF FIRE EXTINGUISHERS**
Selection and demonstration of first-aid fire extinguishers: soda acid, foam, carbon dioxide (CO₂), dry chemical powder, halon.

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**ELECTIVE – I**

**ME 671 – ENVIRONMENTAL POLLUTION CONTROL (3 – 0 – 0) 3**

Air pollution– Classification and properties of Air pollutants-Pollution sources- Control of air pollution – Gravitational settling chambers-Cyclone separators, ESP, Wet scrubber.

Dispersion of Air pollutants-Plume behavior-Control of gaseous pollutants, sulphur dioxides, nitrogen oxides, Carbon monoxide and Hydrocarbons. Air pollution laws and Standards.

Water pollution- Classification of water pollutant and their effects on receiving bodies. Advanced wastewater treatments by physical, chemical, biological and thermal methods-Effluent quality standards.

Pollution control in process industries – Cement, paper, petroleum, fertilizer and petrochemical.

**References**

**ME 672 – SAFETY IN ON AND OFF SHORE DRILLING (3 – 0 – 0) 3**


On and off shore oil operation – Construction of Installation – Pipe line Construction – Maintenance and repair activities – Safety and associated hazards

Drilling oil – Technique and equipment- Work position –Working condition – safety and associated hazards- lighting and its effects

Petroleum Extraction and transport by sea – Oil field products – Operation – Transport of crude by sea – Crude oil hazards.

Petroleum product storage and transport –Storage equipment –Precaution –Tank cleaning

**References**

**ELECTIVE – II, III, IV**

**ME 673 – SAFETY IN CONSTRUCTION (3 – 0 – 0) 3**

General safety consideration – analyzing construction jobs for safety – Contract document – Safety certificate for statutory authorities for old building and construction


Safety in Erection and closing operation - Construction materials –Specifications – suitability – Limitations – Merits and demerits – Steel structures –Concrete structure

Safety in typical civil structures – Dams-bridges-water Tanks-Retaining walls-Critical factors for failure-Regular Inspection and monitoring.

Maintenance –Training-Scheduling-Preventive maintenance-Lock out of Mechanical and Electrical maintenance-ground maintenance-hand tools-Gasoline operating equipment.

**References**
ME 674 - HUMAN FACTORS ENGINEERING (3 – 0 – 0) 3

Concept of man-machine system – Applications of human factors Engineering- Man as Sensor, Man as Information processor, Man as Controller


Factors impending safety – Technological factor – Physiological factor – Legal factor – Administrative factors

Personal protective equipments (different types, specifications, standards, testing procedures, and maintenance).

References

ME 675 - ELECTRICAL SAFETY (3 – 0 – 0) 3


Standards and statutory requirements – Indian electricity acts and rules - statutory requirements from Electrical inspectorate.


Selection of Environment, Protection and Interlock – Discharge rods and earthing device – Safety in the use of portable tools - Preventive maintenance

Hazardous area classification and classification of electrical equipments for hazardous areas (IS, API and OSHA standards).

References
3. www.osha.gov

ME 676 – SAFETY IN MATERIAL HANDLING (3 – 0 – 0) 3

General safety consideration in material handling - Ropes, Chains, Sling, Hoops, Clamps, Arresting gears – Prime movers.

Ergonomic consideration in material handling, design, installation, operation and maintenance of Conveying equipments, hoisting, traveling and slewing mechanisms.
Ergonomic consideration in material handling, design, installation, operation and maintenance of driving gear for hoisting mechanism – Traveling mechanism

Selection, operation and maintenance of Industrial Trucks – Mobile Cranes – Tower crane – Checklist - Competent persons.

Storage and Retrieval of common goods of various shapes and sizes in a general store of a big industry.

References

ME 677 – DESIGN OF AIR POLLUTION CONTROL SYSTEM (3 – 0 – 0) 3


Gaseous Pollutant control: Gas absorption in tray and packed towers – Absorption with / Without chemical reaction – Removal of SO2 – Absorption in fixed blades- Breakthrough.

Removal of HCs / VOCs – NOx removal – Wet scrubbers.

Integrated Air pollution control systems.

References

ME 678 – INDUSTRIAL NOISE AN VIBRATION CONTROL (3 – 0 – 0) 3

INTRODUCTION
Basic definitions and terminology used in Vibrations and acoustics – Mathematical concepts and degrees of freedom in vibratory systems – Natural frequencies and vibration modes – continuous systems and wave theory concept – wave equation and relation to acoustics - theory of sound propagation and terminology involved – Plane wave and spherical waves – Concepts of free field and diffuse field, nearfield and farfield – frequency analysis and vibration and noise spectrum – Signature analysis and condition monitoring.

INSTRUMENTATION AND AUDITORY
Sensors used in vibration and measurements – Frequency and spectrum analysers – Weighting networks – Hearing mechanism – relation between subjective and objective sounds – Auditory effects of noise and audiometric testing – Speech interference levels and its importance.
SOURCES OF NOISE AND RATINGS
Mechanism of noise generation and propagation in various machinery and machine components, vehicles etc. – Directivity index – Concept of Leq and estimation – Noise ratings and standards for various sources like industrial, construction, traffic, aircraft community etc. – industrial safety and OSHA regulations – Noise legislations and management.

NOISE CONTROL

ABATEMENT OF NOISE
Active noise attenuators and scope for abatement of industrial noise.

Text Book

References