M.Tech. Degree

INDUSTRIAL SAFETY ENGINEERING

SYLLABUS
FOR
CREDIT BASED
CURRICULUM

Effective from 2007-08

DEPARTMENT OF MECHANICAL ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY

TIRUCHIRAPPALLI – 620 015.

INDIA

MAY 2007

NATIONAL INSTITUTE OF TECHNOLOGY: TIRUCHIRAPPALLI – 620 015.

DEPARTMENT OF MECHANICAL ENGINEERING

M.Tech. - INDUSTRIAL SAFETY ENGINEERING

The total minimum credits required for completing the M.Tech. Programme in Mechanical Engineering is 62

CODE	COURSE OF STUDY	L	T	P	C
	SEMESTER I				
MA 611	Probability and Statistics	3	1	0	4
ME 653	Safety Management	3	0	0	3
ME 655	Occupational Health and Hygiene	3	0	3	4
ME 657	Safety in Chemical Industry	3	0	0	3
ME 659	Regulation for Health, Safety and Environment	3	0	0	3
	Elective I	3	0	0	3
	Total	**18**	**1**	**3**	**20**
	SEMESTER II				
ME 652	Computer Aided Risk Analysis	3	1	0	4
ME 654	Safety in Material Handling	3	0	0	3
ME 656	Fire Engineering and Explosion Control	3	0	0	3
	Elective II	3	0	0	3
	Elective III	3	0	0	3
	Elective IV	3	0	0	3
	Total	**18**	**1**	**0**	**19**
	SEMESTER III				
ME 797	Project work - Phase I	0	0	0	**12**
	SEMESTER IV				
ME 798	Project Work - Phase II	0	0	0	**12**
	Total Credits				**63**

LIST OF ELECTIVES

SEMESTER – I

ELECTIVE –I

ME 671 - Human Factors Engineering
ME 672 – Environmental Pollution Control

SEMESTER – II

ELECTIVE – II, III & IV

ME 673 – Safety in Construction
ME 674 – Safety in On and Off Shore Drilling
ME 675 - Electrical Safety
ME 676 – Safety in Engineering Industry
CC 614 – Environmental Impact Assessment
CC 617 – Design of Air pollution control system

Any other elective offered by other department

SEMESTER – I

MA 611 - PROBABILITY AND STATISTICS

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.

Basics concepts of reliability - Failure rate analysis – Reliability of systems – Series, Parallel – Maintenance - Preventive and corrective – Maintainability equation – Availability – Quality and Reliability.

References:

1. BOWKER and LIBERMAN, *Engineering Statistics*, Prentice-Hall.

2. GUPTA, S.C. and KAPOOR, V.K., *Fundamentals of Mathematical Statistics*, Sultan Chand and Sons.

3. SPIEGEL, MURRAY R., *Probability and Statistics*, Schaum's series.

4. SPIEGEL, MURRAY R., *Statistics*, Schaum's series.

5. TRIVEDI K.S., *Probability and Statistics with Reliability and Queueing and Computer Science Applications*, Prentice Hall of India.

ME 653 – SAFETY MANAGEMENT

CONCEPTS

History of Safety movement –Evolution of modern safety concept- general concepts of management – planning for safety for optimization of productivity -line and staff functions for safety- budgeting for safety- safety policy.

TECHNIQUES

Incident Recall Technique (IRT), disaster control, job safety analysis, safety survey, safety inspection, safety sampling, Safety Audit.

ACCIDENT INVESTIGATION AND REPORTING

Concept of an accident, reportable and non reportable accidents, reporting to statutory authorities – principles of accident prevention – accident investigation and analysis – records for accidents, departmental accident reports, documentation of accidents – unsafe act and condition – domino sequence – supervisory role – role of safety committee –cost of accident.

SAFETY PERFORMANCE MONITORING

ANSI (Z16.1) Recommended practices for compiling and measuring work injury experience – 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 – programmes, 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

1. Accident Prevention Manual for Industrial Operations", N.S.C.Chicago, 1982
2. Heinrich H.W. "Industrial Accident Prevention" McGraw-Hill Company, New York, 1980.
3. Krishnan N.V. "Safety Management in Industry" Jaico Publishing House, Bombay, 1997.
4. John Ridley, "Safety at Work", Butterworth & Co., London, 1983.
5. Blake R.B., "Industrial Safety" Prentice Hall, Inc., New Jersey, 1973

ME 655 – OCCUPATIONAL HEALTH AND HYGIENE

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 Musculoskeltal 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

Man as a system component – allocation of functions – efficiency – occupational work capacity – aerobic and anaerobic work – evaluation of physiological requirements of jobs – parameters of measurements – categorization of job heaviness – work organization – stress – strain – fatigue – rest pauses – shift work – personal hygiene.

References:

1. *Handbook of Occupational Health and Safety,* NSC Chicago, 1982
2. *Encyclopedia of Occupational Health and Safet*y, Vol. I & II, International Labour Organisation, Geneva, 1985.
3. McCornick, E.J. and Sanders, M.S., *Human Factors in Engineering and Design*, Tata McGraw-Hill, 1982.

ME 657 – SAFETY IN CHEMICAL INDUSTRY

Safety in the design process of chemical plants- safety in erection and commissioning of chemical plants- safety in material handling – Pressure and leak testing.

Safety in operational and maintenance – Exposure of personnel, Operational activities and hazards – Work permit systems entry into confined space where toxic contaminants are present

Safety in storage and Handling of chemical and gases – Hazards during transportation – pipeline transport – safety in chemical laboratories.

Toxic release and control methodologies – toxic effects- threshold limit values – Awareness and preparedness for energy at local level

Specific safety consideration for Cement, paper, pharmaceutical, petroleum, petro-chemical, rubber, fertilizer and distilleries.

References

1. Lees, F.P., *Loss Prevention in Process Industries,* Butterworths, NewDelhi, 1986.
2. *Accident Prevention Manual for Industrial Operations,* NSC, Chicago, 1982.

ME 659 – REGULATIONS FOR HEALTH, SAFETY AND ENVIRONMENT

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

1. The Factories Act 1948, Madras Book Agency, Chennai, 2000
2. The Environment Act (Protection) 1986, Commercial Law Publishers (India) Pvt.Ltd., New Delhi.
3. Water (Prevention and control of pollution) act 1974, Commercial Law publishers (India) Pvt.Ltd., New Delhi.
4. Air (Prevention and control of pollution) act 1981, Commercial Law Publishers (India) Pvt.Ltd., New Delhi.
5. Explosive Act, 1884 and Explosive rules, 1883 (India), (2002), Eastern Book company, Lucknow, 10th Edition
6. The manufacture, storage and import of hazardous chemical rules 1989, Madras Book Agency, Chennai.
7. ISO 9000 to OHSAS 18001, Dr. K.C. Arora, S.K. Kataria & Sons, Delhi

SEMESTER – II

ME 652 – COMPUTER AIDED RISK ANALYSIS

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

1. Loss Prevention in Process Industries-Frank P. Less Butterworth-Hein UK 1990 (Vol.I, II & III)
2. Methodologies for Risk and Safety Assessment in Chemical Process Industries, Commonwealth Science Council, UK
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.
5. Guidelines for Hazard Evaluation Procedures, Centre for Chemical Process safety, AICHE 1992.

ME 654 – SAFETY IN MATERIAL HANDLING

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

1. *Accident Prevention Manual for Industrial Operations*, NSC, Chicago, 1982.
2. Alexandrov, M.P., *Material Handling Equipment*, Mir Publishers, Moscow, 1981.
3. Rudenko N., *Material Handling Equipments*, Mir Publishers, Moscow, 1981.

ME 656 – FIRE ENGINEERING AND EXPLOSION CONTROL

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.

Bulding 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.

Statutory Rules and Techniques of fire fighting - Indian Explosive acts and rules – Techniques of fire fighting and demonstration.

References

1. James, D., *Fire Prevention Handbook,* Butterworths, London, 1986.
2. Gupta R.S., *Handbook of Fire Technology,* Orient Longman, Bombay, 1997.

ELECTIVE - I

ME 671 - HUMAN FACTORS ENGINNERING

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

Human Behavior – Individual difference –Motivation –Frustration and Conflicts – Attitudes - Learning concepts.

Principles of Ergonomic – Application of ergonomics in a work system – Principle of motion economy – effects of environment.

Factors impending safety – Technological factor –Physiological factor –Legal factor – Administrative factors
Personal protective equipments (different types, specifications, standards, testing procedures, and maintenance).

References

1. McCornick, E.J., *Human Factors in Engineering and Design,* Tata McGraw-Hill, 1982.
2. *Accident Prevention Manual for Industrial Operations,* NSC, Chicago, 1982.

ME 672 – ENVIRONMENTAL POLLUTION CONTROL

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.

Solid waste management- methods of collection – Disposal of solid waste, land filling, Handling of toxic and radio active wastes –Incineration and vitrification.

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

REFERENCES:

1. Rao, CS, “Environmental pollution engineering:, Wiley Eastern Limited, New Delhi, 1992.
2. S.P.Mahajan, “Pollution control in process industries”, Tata McGraw Hill Publishing Company, New Delhi, 1993.
3. Varma and Braner, “Air pollution equipment”, Springer Publishers, Second Edition.

ELECTIVE – II, III, IV

ME 673 – SAFETY IN CONSTRUCTION

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

Excavation, foundation and utilities – Cordoning – Demolition – Dismantling –Clearing debris – Types of foundations – Open footings.

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

1. *Accident Prevention Manual for Industrial Operations*, NSC, Chicago, 1982.
2. Fulman, J.B., *Construction Safety, Security, and Loss Prevention,* John Wiley and Sons, 1979.

ME 674 – SAFETY IN ON AND OFF SHORE DRILLING

Petroleum and Petroleum products – Fuels- Petroleum solvents – Lubricating oils – Petroleum wax, greases – Miscellaneous product

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

1. *Encyclopedia of Occupational Health and Safet*y, Vol. II, International Labour Organisation, Geneva, 1985 & I.

ME 675 - ELECTRICAL SAFETY

Review of Electrical concept, Electrostatic – Electro magnetism – Stored energy – Working principle of major electrical equipment – Typical supply situation

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

Electrical Hazards – Energy leakage – Clearance and insulation – Excess energy – Current surges – Electrical causes of fire and explosion – National electrical Safety code.

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

1. Fordham Cooper W., *Electrical Safety Engineering*, Butterworths, London, 1986.
2. *Accident Prevention Manual for Industrial Operations*, NSC, Chicago, 1982.
3. www.osha.gov

ME 676 – SAFETY IN ENGINEERING INDUSTRY

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.

Selection and suitability: lathe-drilling-boring-milling-grinding-shaping-sawing-shearing-presses-forge hammer-flywheels-shafts-couplings-gears-sprockets wheels and chains-pulleys and belts-authorized entry to hazardous installations-benefits of good guarding systems.

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.

Health and welfare measures in engineering industry-pollution control in engineering industry-industrial waste disposal.

References

1. "Accident Prevention Manual" – NSC, Chicago, 1982.
2. "Occupational safety Manual" BHEL, Trichy, 1988.
3. "Safety Management by John V. Grimaldi and Rollin H. Simonds, All India Travelers Book seller, New Delhi, 1989.
4. "Safety in Industry" N.V. Krishnan Jaico Publishery House, 1996.
5. Indian Boiler acts and Regulations, Government of India.
6. Safety in the use of wood working machines, HMSO, UK 1992.
7. Health and Safety in welding and Allied processes, welding Institute, UK, High Tech. Publishing Ltd., London, 1989.

CC 614 – ENVIRONMENTAL MPACT ASSESSMENT

Evolution of EIA – Concepts – Methodologies – Screening – Scoping – Mitigation – Matrices – Checklist.

Rapid and Comprehensive EIA – Legislative and Environmental Clearance procedure in India – Prediction tools for EIA.

Assesment of Impact – Air – Water – Soil – Noise- Biological.

Socio cultural environment – Public participation – Resettlement and Rehabilitation.

Documentation of EIA – Environmental management plan – Post project monitoring – Environmental Audit- Life cycle assessment – EMS – case studies in EIA.

References:

1. Canter. R. L., *Environmental Impact Assessment*, McGraw Hill.
2. John G. Rau and David. C. Wooten (Ed)., *Environmental Impact analysis hand book,* McGraw Hill Book Company.

CC 617 – DESIGN OF AIR POLLUTION CONTROL SYSTEM

Industrial sources of Air Pollution – Emission factors – Regulations – Control Strategies – Policies.

Particulate pollutant control: Settling chambers – Laminar and Turbulent flow - Filtration – Interception – Impaction – Convective diffusion – Collection of particles by fibers and Granular beds – Electrostatic precipitation – Cyclones – Wet Collectors.

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:

1. Lawrence. K. Wang, Norman. C Perelra, Yung-Tse-Hung., *Air Pollution Control Engineering,* Tokyo.
2. Noel de Nevers, *Air Pollution Control Engineering*., McGraw Hill, New York.