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Fire, Explosive and Environment Safety Technologies

Technology Focus
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Technology Focus focuses on the technological developments in the organisation covering the products, processes and technologies.

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From the Desk of Guest Editor

"Centre for Fire Explosive & Environment Safety" (CFEES) undertakes R&D projects resulting in products, processes and technologies in the areas of fire, explosive and environment safety. Apart from R&D activities CFEES also plays a very important regulatory and advisory role in the field of fire, explosive and environment safety for various MoD establishments.

In the area of fire safety and research, Low Pressure Water Mist-based fire fighting system has been installed in a nuclear submarine, S3 and testing are under progress.

In the area of fire suppression system for Armoured Fighting Vehicles, 02 prototypes of wireless IFDSS have been successfully developed, for testing in BMP and Arjun tanks. Miniaturised IFDSS has been developed successfully for Arjun MBT MK-II which will be now subjected to DGQA evaluation. User trials for IFDSS for T-72 Tank have been successfully conducted at MFFR, Suratgarh. Wireless IFDSS has also been developed. Also, linear thermal detector is indigenously designed and developed for detection of fire in the engine compartment of AFVs.

Design and synthesis of new organic molecules to be used as Halon Alternatives (NOMHA) was taken up with the aim of developing chemical substitutes to Halon 1211 and Halon 1301, having zero ozone depletion potential, lowest possible atmospheric lifetime and global warming potential, besides low toxicity and meeting the criteria of Montreal and Kyoto protocols.

The National Halon Banking and Management Facility has been revived and made operational and more than 30 tons of Halon gas from phased-out cylinders have been recovered. This Halon is available for critical applications in MoD. In the area of explosive safety, the design of vertical shaft-based underground explosive storage facilities up to 40MT MEC storage capacity has been validated by conducting field trials at 1/10th and 1/5th scale at Borkhedi, Nagpur. There is a 50 per cent reduction in the safety distances as compared to the conventional underground explosive storage facilities.

In the area of material development for explosive safety, indigenous polyurea formulations, capable of bestowing blast mitigating properties to existing masonry structures, have been successfully developed and evaluated in shock tube facility at CFEES. Master Ammunition Storage Plan (MASP), based on new designs of explosive buildings IGLOO, URP, HPM & UG for ammunition echelons was developed which will cater to the prospective planning of ammunition depots of army and navy. QRA tool developed by CFEES was presented to the apex body Storage and Transportation of Explosives Committee (STEC), which has representations from all the stakeholders in MoD. It was subsequently ratified by STEC. In the area of environmental safety, the main challenge is disposal of explosive/ hazardous waste using eco-friendly technologies. Different disposal technologies, viz., adsorption, advanced oxidation process and bio-remediation have been developed.

CFEES has formulated "Guidelines for E-waste Management in DRDO" with an intent to provide an institutional framework to manage E-waste in an environmentally prudent manner and consistent with the existing national rules for E-waste management.

CFEES is extremely thankful to Ms. Nabanita Radhakrishnan, Director General (SAM), DRDO for inspiring to bring out this issue as a quick reference for *Technology Focus*.

RAJIV NARANG

Outstanding Scientist & Director
CFEES

Fire, Explosive and Environment Safety Technologies

DRDO has made outstanding contributions in the vital areas of safety management; development of systems, devices, processes and materials in the fields of fire, explosives and environment safety for defence services and Ministry of Defence (MoD) establishments through its concerted R&D efforts.

Centre for Fire, Explosive and Environment Safety (CFEES), an establishment of DRDO plays a unique regulatory and advisory role in MoD such as safety advice, audit, regulations and compliance of Storage and Transport of Explosive Committee (STEC), siting of explosive storages facilities and fire advisory. CFEES is also a member of Environment Safety Committee (ESC) for Indian Navy and Ozone Cell of Ministry of Environment and Forests (MoEF). Apart from advisory and regulatory duties, the R&D work accomplished by the laboratory encompasses wide spectrum of activities like design and development of systems, design of new facilities and processes in three areas, viz.,

- ◊ Fire science and fire protection engineering;
- ◊ Explosive safety in the areas of storage and handling of ammunition and explosives;
- ◊ Environmental management and hazardous waste treatment for MoD

The R&D achievements of the lab provided continuous technology inputs for evolving more efficient and practical safety practices in the area of fire, explosives and environment safety. Besides providing consultancy to government departments, public and civil sector units on explosives/fire/environment safety related matters, the lab conducts special courses and provides training to personnel of defence services, inter service organisations, ordnance factories and other defence undertakings. It also plays a pivotal role in safety management in DRDO.

Fire Safety Technologies

Wireless Instant Fire Detection and Suppression System

The system meant for Armoured Fighting Vehicles (AFV) detects and suppresses the hydrocarbons fuel fire in crew compartment in less than 130 msec by using intelligent dual spectrum IR detectors and in engine compartment in less than 10 sec by using linear thermal detector having wired as well as wireless mode of communication among different sub-systems.

Salient Features

- ◊ Two wireless protocols options are provided one working on Zig Bee (2.4 GHz) and other working on UWB (3.5 GHz – 6.5 GHz)
- ◊ System has optional wired communication using CAN 2.0A protocol
- ◊ Detects fire signature using intelligent detectors
- ◊ Immune to false alarm sources and meets MIL-Prf 62546C performance standard
- ◊ System will work even if cable gets ruptured
- ◊ System is independent of Master Control Unit (MCU), working on mesh topology
- ◊ Detectors, Firewire Interface Unit (FIU) and Cylinder Interface Unit (CIU) has in built capacitors
- ◊ System is JSS55555 Environmental std qualified and is MIL-Std 461E qualified

Linear Thermal Detector for Engine Compartment of AFVs

Linear thermal detector is coaxial cable in which negative temperature co-efficient material is filled between outer sheath and central conductor. The detector is required to be indigenously designed and developed for detection of fire in engine compartment of AFVs. It provides overheat warning and actuates fire extinguisher in case of fire in engine compartment of AFVs.

There were challenges to identify material for outer sheath, central conductor and material to be filled between outer and central conductor and fabrication of linear thermal detector indigenously. To develop

such detector, study of combination of the metal/alloy for center electrode, outer conductor and metal oxide for NTC materials, heat conduction from outer layer to central electrode in transient as well as in steady state condition have been carried out. Fabrication process has been finalised. Design and development of linear thermal detector having 2.5 mm outer diameter and 10 feet length has been carried out. Testing and evaluation of prototype has been done successfully. Resistance between outer sheath and inner conductor decreases with increase in temperature. Cost of indigenously developed linear thermal detector will be approx. 60 per cent lesser as compared to imported fire wire.

Design & Synthesis of New Organic Molecules to be used as Halon Alternative

During the past 30 years it has become widely accepted that the release of volatile man-made halocarbons (notably CFCs and Halons) into the earth's atmosphere causes depletion of stratospheric ozone. In response to society's concern over potential effects of ozone depletion, a variety of national and international regulations have been promulgated, the best known being the Montreal Protocol on substances that deplete the Ozone layer.

Under Halocarbon Chemicals, Halon 1301 (Bromotrifluoromethane, CF3Br) and Halon 1211 (Bromochlorodifluoromethane, CF2ClBr) were extensively used as clean fire extinguishants in 1960s and 1970s. These chemicals have very high Ozone Depletion Potential (ODP). From 1974 onwards, it was globally realized that halocarbons are responsible for the damage of stratospheric ozone layer and their use was banned by the Montreal Protocol. Thus, in the absence of Halons, the excellent fire fighting chemicals, the search for alternatives was begun, resulting in identification of compounds from various groups like Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), etc. as alternative to Halon. As an outcome of worldwide R&D for development of halon alternatives, many chemicals have emerged out as halon alternatives that are listed in NFPA 2001, Standard on Clean Agent Fire Extinguishing Systems.

Consequent to these reasons, CFEES took up a project, titled, "Development of Heptafluoropropane and its Fire Protection System" in 2004 and successfully developed the Heptafluoropropane (considered as closest substitute of Halon 1301) through an indigenous process, which was patented. The technology was demonstrated at pilot plant scale and subsequently transferred to industry.

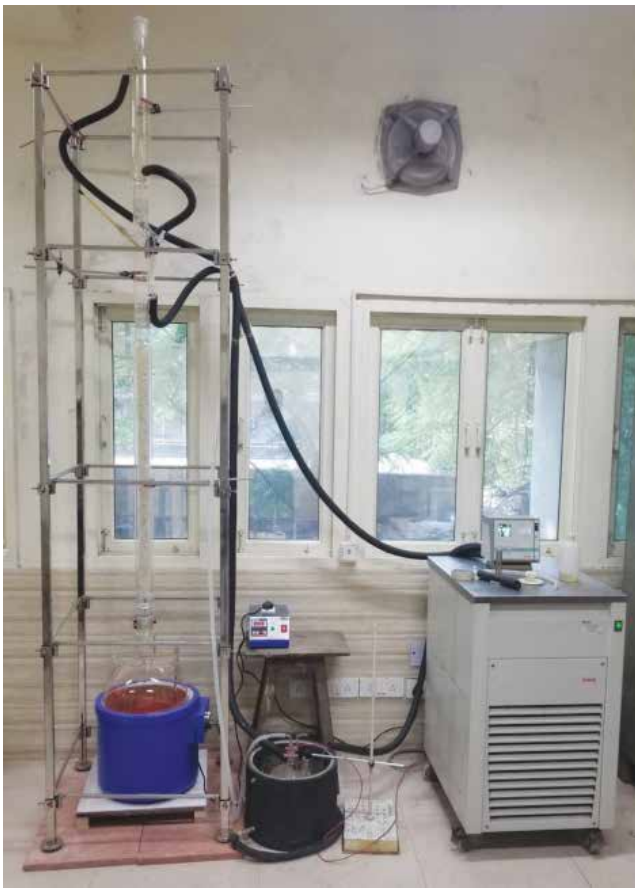
Besides, the Montreal Protocol, another International Protocol known as Kyoto Protocol was adopted which aims at fighting global warming by limiting release of greenhouse gases into the atmosphere. Consequent to this protocol, the production of HFCs, PFCs having high global warming potential has to be restricted by signatory countries.

To meet futuristic requirements of armed forces for their strategic applications, DRDO and other public sectors and to maintain compliance to the international environmental norms, it was further required to develop new compounds having better environmental parameters that could have been used for fire fighting applications.

Subsequently, another project, entitled "Design and Synthesis of New Organic Molecules to be Used as Halon Alternatives (NOMHA)",was taken up with the aim of developing chemical substitutes to Halon 1211 & Halon 1301, having zero ODP, lowest possible Atmospheric Lifetime (ALT) and Global Warming Potential (GWP), besides low toxicity and meeting the criteria of Montreal and Kyoto protocols.

The compounds targeted to be synthesized under this project comprised of perfluoroketones, bromoalkenes, perfluoroiodoalkanes, haloethers, cycloalkanes and Phosphorus containing compounds. Besides synthesis and characterization of the synthesized compounds, project objectives also comprised of evaluation of fire suppression efficacies, preliminary toxicity data, optimization of synthetic methodologies and subsequent scale-up of qualified compounds. In concern to this, following products developed.

Screening tool for fire suppression efficacy



Bench Scale (20 L) reaction-cum-distillation

Semi-automatic standard-cup-burner setup

Synthesis and characterization of designed/targeted molecules (30 Nos.)

19 Nos. of molecules synthesized and characterized by NMR, Mass and IR-Spectroscopy.

Performance evaluation (MEC determination) of synthesized molecules

- Acute toxicity study, LD50 (Oral and dermal) and PSII carried out at Defence Research & Development Establishment (DRDE), Gwalior in r/o 10 no. of synthesized molecules, for which, sufficient quantity was available
- Five no. of molecules shortlisted based on preliminary toxicity data
- Considering the volatility three no. of compounds shortlisted for preliminary MEC evaluation: MEC determined against Class-C fire by FID-based screening tool for MEC determination
- Environment Impact Parameters (viz. ODP, GWP and ALT) of these three (03) compounds were determined at Bhabha Atomic Research Centre (BARC), Mumbai and found the values were within permissible limits
- All the three (03) molecules found prominent for scale-up based on their volatility, preliminary MEC and toxicity data and EIP
- MEC of above compounds determined against Class-B fire using indigenously developed automatic standard cup-burner apparatus

Optimization of methods for synthesis and up scaling of promising molecules

Optimization done for method of synthesis for two shortlisted molecules, i.e., 2,2,2-trifluoroiodoethane and 2,2,3,3,3-Pentafluoropropanol. Upscaling of both the compounds done to 1Kg/batch level.

The following facilities were developed/created

- Semi-automatic standard cup-burner setup
- Screening tool for fire suppression efficacy
- Bench Scale (20 L) reaction-cum-distillation

Low Pressure Twin Fluid Water Mist Technology for Fire Protection onboard Naval Platforms

Fire suppression technology, which has been accepted worldwide for its fire extinguishment capability, particularly for naval applications. On recommendation of Indian Navy, a project for validation of water mist system for its fire protection application in ship engine room and other machinery spaces has been taken up. Under this project, a low pressure twin-fluid water mist system has been developed and validated to provide the most effective and quick means of fighting major fires inside the compartments and provide comprehensive fire protection cover across the naval platform. It allows for an instant response to a fire situation, in that, it is non-toxic, does not require spaces to be sealed or evacuated and can be deployed in HV and machinery spaces. The mist acts in several ways to fight fire but can also be used to prevent flashovers and pre-emptively cool compartments. This system can be automatically activated on detection of a fire by heat/smoke detectors. Manual interventions and the use of portable extinguishers may be required after fire is controlled to extinguish the concealed or obstructed fires.

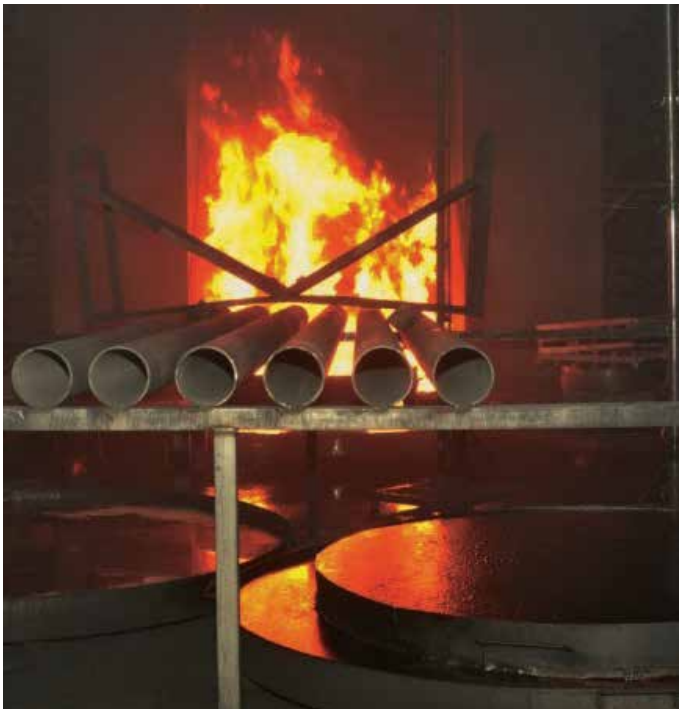
CFEES mist system utilizes an indigenously designed twin-fluid internally mixing type nozzle which works at 2-4 bar pressure of water and 4-6 bar pressure of air or nitrogen gas for generation of water mist with Sauter Mean Diameter (SMD) less than 50 μm and mist generation rate in the range 1-3 LPM. A Patent has been filed for the developed nozzle entitled "An atomizer and a total flooding twin fluid-based fire protection system comprising the same".

The interaction of a water mist with a fire is affected by the processes of atomization and droplet dispersion, heat and mass transfer and relative position of mist atomizers and fire. These parameters together with external factors, such as, compartment geometry, ventilation conditions, fuel properties and fire size affect the fire suppression performance of mist. Based on large no. of experiments (>100 nos.) in different scale chambers at CFEES on fires ranging from 5 kW/m^3 to 20 kW/m^3, CFEES has developed a relation which defines that the product of Minimum Extinguishing Concentration (MEC) and square root of Heat Release Rate (HRR) is constant for an enclosure and dependent upon the enclosure height. The experimental study carried out by CFEES demonstrated that the developed relationship is applicable for wide range of mist with SMD as 20 μm–100 μm and enclosure heights upto 5 m. Using this relationship, low pressure twin fluid water mist system has been designed by total flooding of the space with mist of SMD less than 50 μm. For validation of performance a 1000 m^3 chamber was fabricated,

1000 m^3 engine fire simulation facility

installed and commissioned at CFEES. This chamber was simulated as ship engine room compartment and instrumented with various sensors, thermocouples, video imaging, etc. to monitor the performance of water mist system. The performance was evaluated as per the fire scenarios that may occur in a naval ship engine room and those mentioned in IMO Circ 1165. The water mist system has been demonstrated to suppress various types of Class A and Class B pool and spray fires within 120 s with thermal management (compartment temp. ≤ 60 °C) achieved within 60 s as against the IMO qualification criteria of 900 s and 300 s (for 100 °C), respectively.

1000 m^3 fire simulation facility used for validation of performance of water mist system and its inside view are shown. Two fire scenarios used for performance evaluation of the mist system for engine area fires are also shown in Figures.



2.5 m diameter pool fire under the bilge plate & engine mock-ups

1.46 m diameter pool fire and wood crib fire on the bilge plate near the engine mockups

Inside view of the 1000 m^3 fire simulation facility with ship engine mockups

Explosive Safety Technologies

Re-classification of HEER Shell 155 mm from UNHD 1.1 to UNHD 1.2 by modifying the Packaging

On mediumization, all Arty Guns, i.e., 75/24, 105 mm and 130 mm are being replaced to 155 mm Arty Guns in Indian Army. In the present packaging, 155 mm shells are of UNHD 1.1 hazard classification which has mass explosion hazard and require very large safety distances (IQD & OQD). Hence there is a requirement of additional land for storage, which is not available. One of the solution is to convert hazard classification of 155 mm ammunition (70 % of whole authorization) from UNHD 1.1 to UNHD 1.2 by modification of the packaging. UNHD 1.2 has mass projection hazard with reduced safety distances. In ammunition of UNHD 1.2, sympathetic detonation from one package to other is avoided and the size of explosion (Maximum Credible Event) in case of an accident is much lower. For a standard magazine of 136 MT NEC, the inhabited safety distances (OQD) for UNHD 1.1 is 1145 m where as for UNHD 1.2 it is 560 m. Similarly, the magazine safety distances (IQD) is reduced from 125 m to 30 m. Therefore, the capacity of a depot increases many fold due to conversion to UNHD 1.2 by change in packaging of ammunition.

The following are the advantages of converting ammunition of UNHD 1.1 to UNHD 1.2:

◊ Huge reduction in size of explosion in case of accident (Reduced maximum credible event). In case of 155 mm shells, it reduces from 220,000 kg to approximate 10 kg of NEC.

Conventional packaging of HEER shell 155 mm

Modified packaging of HEER shell 155 mm

- ◊ It will result in reduction in safety distances both IQD and OQD
- ◊ The storage capacity of a depot will increase many times by reducing QDs (from 7200 MT to almost 400,000 MT)
- ◊ It will result in reduction in cost of a shed as no traverses will be required for UNHD 1.2 ammunition
- ◊ No OQD is required if UNHD 1.2 Amn is stored in ECM (Igloo) or UG Magazine
- ◊ It will result in substantial saving to the exchequer, considering the saving of land and enhancing capacity of existing depots

Feasibility Study

Feasibility trials were carried out with 155 mm HEER shells in modified pallets. The shell configurations for conventional and modified pallets are shown in Figures. During the feasibility trials, single package test was repeated 3 times with modified pallet. Each time, 8 shells went off in low-order detonation and 3 shells were found intact. Also to compare the results, single package test was carried out with conventional pallet in which all shells went off in high order detonation sympathetically. Hence, Reclassification test of HEER Shell 155 mm in modified packaging was carried out as per UN Test series 6.

Single package test, stack test and bonfire test were carried out with modified packaging as per UN Test Series 6. Through the trials it was proved that HEER Shell 155 mm in modified packaging was meeting all the criteria laid down for re-classification as UNHD 1.2. Hence, it has been classified as UNHD 1.2 in modified packaging.

Vertical Shaft-based Underground Explosive Storage Structures

Armed forces are facing acute shortage of land for siting of new explosive/ammunition storage facilities. A similar problem exists even in case of existing facilities, due to increased explosive holdings and reduction in safety zones around storage facilities due to encroachment. This has led to requests from armed forces for design of explosive storage structures with reduced safety distances.

Underground explosive storage structures require lesser safety distances. CFEES had conducted design validation trials with 1100 kg NEC HD 1.1 in twin chambered underground explosive storage structure with adits which led to formulation of quantity distance matrix for underground explosive storage structures. OQD for these structures is 8 W1/3 as compared to 22.2 W1/3 required for aboveground explosive storage structures.

However, underground explosive storage structures with adits (conventional design) require large footprint for construction and has a considerably higher cost as compared to aboveground storage structures. To overcome these problems, CFEES has come out with an innovative design of vertical shaft-based underground storage structures.

Fully instrumented six scaled down (1/15th, 1/10th and 1/5th) blast trials of 40 Ton NEC capacity underground explosive storage structure with vertical shaft has been conducted at Borkhedi, Nagpur. Blast pressure inside the donor chamber, access tunnels, main tunnel, expansion chambers and in vertical shafts have been recorded. In the field, blast pressure and ground shock at various distances were measured. Based on the instrumentation data obtained in the blast trials, safety template has been established.

Using the data obtained in blast trials, scaling laws have been established for design of vertical shaft-based underground explosive storage structures. These scaling laws would aid in quick and efficient design of vertical shaft based underground explosive storage structures, which would cater to all User requirements for all geographical locations across the country.

Vertical shaft-based underground explosive storage structure configuration has several advantages over conventional underground explosive storage structures as given in Table:

Parameter	Conventional UG structure (20 Ton X 3 Chambers)	Vertical Shaft-based UG structure (20 Ton X 3 Chambers)	Saving
OQD	450 m x 600 m	475 m x 290 m	50 %
Footprint required for construction	270 m x 210 m	325 m x 100 m	45 %
Construction cost	₹ 225 Cr	₹ 75 Cr	66 %

Polyurea Coatings for Mitigation of Blast Effects

In the wake of terrorist threats, enormous attention is nowadays being directed towards designing of strategic buildings, where such a possibility is even remotely envisioned. Terrorist attacks usually take the form of small bombings, which lead to structural damage, generating high velocity fragments; the extent of damage being dependent on the amount of explosive employed.

To reduce the extent of damage, one of the solutions envisaged involves enhancing the strength of existing structures, which in turn can be achieved through retrofitting. Some of the existing solutions to improve blast-mitigating performance are maintaining a sufficient stand-off distance, increasing its mass and ductility, external-strengthening techniques using composite laminate/ steel jacketing and retrofitting the structure with additional light-weight layers, e.g., Fibre Reinforced Polymer (FRP) and elastomeric coatings.

Elastomeric Coatings

Among the many desirable properties of any retrofitting polymer, the most important include ease of application, rapid cure time, adhesive properties and excellent mechanical properties, particularly strength and elongation. Polyurea coatings are being advocated as excellent candidates for retrofitting applications, particularly for blast mitigation and ballistic protection. In view of the same, it is considered of interest to develop indigenous polyurea formulations, which aid in improving the blast survivability of existing structures and also used as a protective coating on military vehicles.

CFEES undertook a S&T project on "Development of Polymeric Coating for Mitigation of Blast Effects (ST/14-15/CFE-1311) in the year 2015. The project was taken up with an aim to develop indigenous polyurea formulations with a minimum tensile strength of 13 MPa and a minimum elongation of 100 per cent. Under the project, a polyurea spraying facility has been setup at CFEES. Indigenous polyurea formulations have been developed, which met the desired mechanical properties as targeted under the project (Tensile strength 15.6 ± 0.5 MPa and elongation of 265± 9%). Subsequently, extensive shock tube studies have been conducted at CFEES, where both neat and coated concrete tiles were subjected to controlled blast loadings. Unreinforced concrete tiles underwent extensive fragmentation at peak pressures ~50 psi, while the polyurea coated tiles could withstand much higher peak pressures.The extent of mitigation increased with the coating thickness and composites with 6 mm polyurea could withstand 87 psi. At higher loadings (Pr = 90 psi), polyurea-concrete debonding was evidenced, however the membrane arrested the fragments formed. Dynamic mechanical studies reveal that the "glass transition" phenomenon in polyurea mandated excessively high frequencies ($V \sim 10^{15}$ Hz) under ambient temperatures. The technology is being transferred to private vendors through DI2TM for application in civil sector and military.

Application Of Quantitative Risk Assessment

Ammunitions and explosives are stored at safe distances from susceptible sites, although it is impracticable to prescribe distances which would guarantee absolute safety. On the basis of the effects of an explosion (e.g., blast and fragment radii) and predictions of injury or damage, safe distances corresponding to different explosive quantities are given in Quantity Distance (QD) Tables and are the foundation for siting of ammunition and explosives storage magazines/processing facilities in MoD.

Indian armed forces and defence production agencies are facing acute shortage of land for ammunition storage facilities and the crisis is intense even in the case of existing ones due to the increased explosive holdings and reduction in safety zones around storage facilities due to encroachment. This has often led to requests for reduction in the enforcement of safe separation distances as prescribed by QD table and has not yet been addressed adequately.

A risk based approach known as Quantitative Risk Assessment (QRA) is a scientific and systematic approach to estimate and quantify potential loss of life, caused by undesired events and has been recognized by several countries as complementary to QD approach. QRA considers the likelihood of an accident based on the type of activity, number of people involved and the design/construction of the facility and estimates the consequences of deviating from QD. It is especially useful for assessing the risk due to deviation from QD, due to increased operational holdings/non availability of land/encroachment.

QRA tool developed by CFEES was presented to the apex body, which has representations from all the stakeholders in MoD. It was subsequently ratified by STEC.

Hazard Classification of Explosives/ Propellants/ Ammunition

As per regulations, it is necessary that no explosives are conveyed, stored or supplied unless they have been classified for transport and/or storage (i.e., packaged or unpackaged as appropriate) and are labeled in accordance with regulations. It is required to control the operational conditions with reasonable regard to safety of life and property. The classification is assigned on the basis of analogy and hazard classification trials. The trials are conducted by CFEES and then ratified by STEC. CFEES conducted hazard classification of explosive articles Signals Railway Track, Explosive-Fog Signal developed by Ordnance Factory, Dehu Road and Canopy Severance System (CSS) developed by Armament Research & Development Establishment (ARDE) in association with High Energy Materials Research Laboratory (HEMRL).

The Signals Railway Tracks are coin sized devices which are deployed on the railway tracks and function due to pressure when train passes over it and produce loud warning signal to train drivers during fog conditions, when visibility is very low so as to avoid accidents. Ten fog signals are packed in a plastic container. Twenty such plastic containers are packed in laminated corrugated box.

CSS is the mechanical explosive system consisting of various explosive elements such as pressure-actuated initiators with detonators, junction box with booster, Explosive Transfer Lines (ETLs) of different lengths and Miniature Detonating Cord (MDC) and attenuators which works on the principle of controlled propagation of detonation wave to break the canopy of fighter aircrafts. All these components are integrated together and installed on the canopy of fighter aircraft for cutting the canopy of fighter aircraft which paves the way for smooth ejection of pilot during in-flight as well as on ground emergencies. Various explosive elements are placed in three layers of foam inside FRG packages. These were required to be transported to U.K. by air; hence hazard classification of CSS was required.

For both the compounds, trials were conducted as per UN Test Series 6 of UN Manual "Tests and Criteria for the Classification of Explosive

Substances and Articles". The test series 6 consists of three types of tests, i.e., single package test, stack test and bonfire test. Single package tests were conducted to determine if there is mass explosion of the total contents. Stack test was conducted to determine whether an explosion is propagated from one package to another. This test was waived off as in single package test there was no propagation of explosion from one article to another. Bonfire test was performed on packages of explosive articles, to determine whether there is a mass explosion or a hazard from dangerous projections, radiant heat and/or violent burning or any other dangerous effect when involved in a fire. Unconfined package test for compatibility group S was also carried out.In the single package tests, there was neither crater formation nor any dent on the witness place. During the Bonfire test, there was neither a fireball nor any projection. During the test for compatibility group 'S', there was no indentation on the witness plate and no flash was observed on adjacent material. As per trial results, the hazard classification code 1.4 S was assigned to Signals, Railway Track as well as to CSS.

Trials Fog Signals, Railway Track

No Propagation to adjacent packages
(Single Package Test)

Fog Signals, Railway Track

Bonfire Test

Unconfined Package Test for Compatibility Group S

Trials Canopy Severance System

Canopy Severance System Package in open condition

After Single Package Test

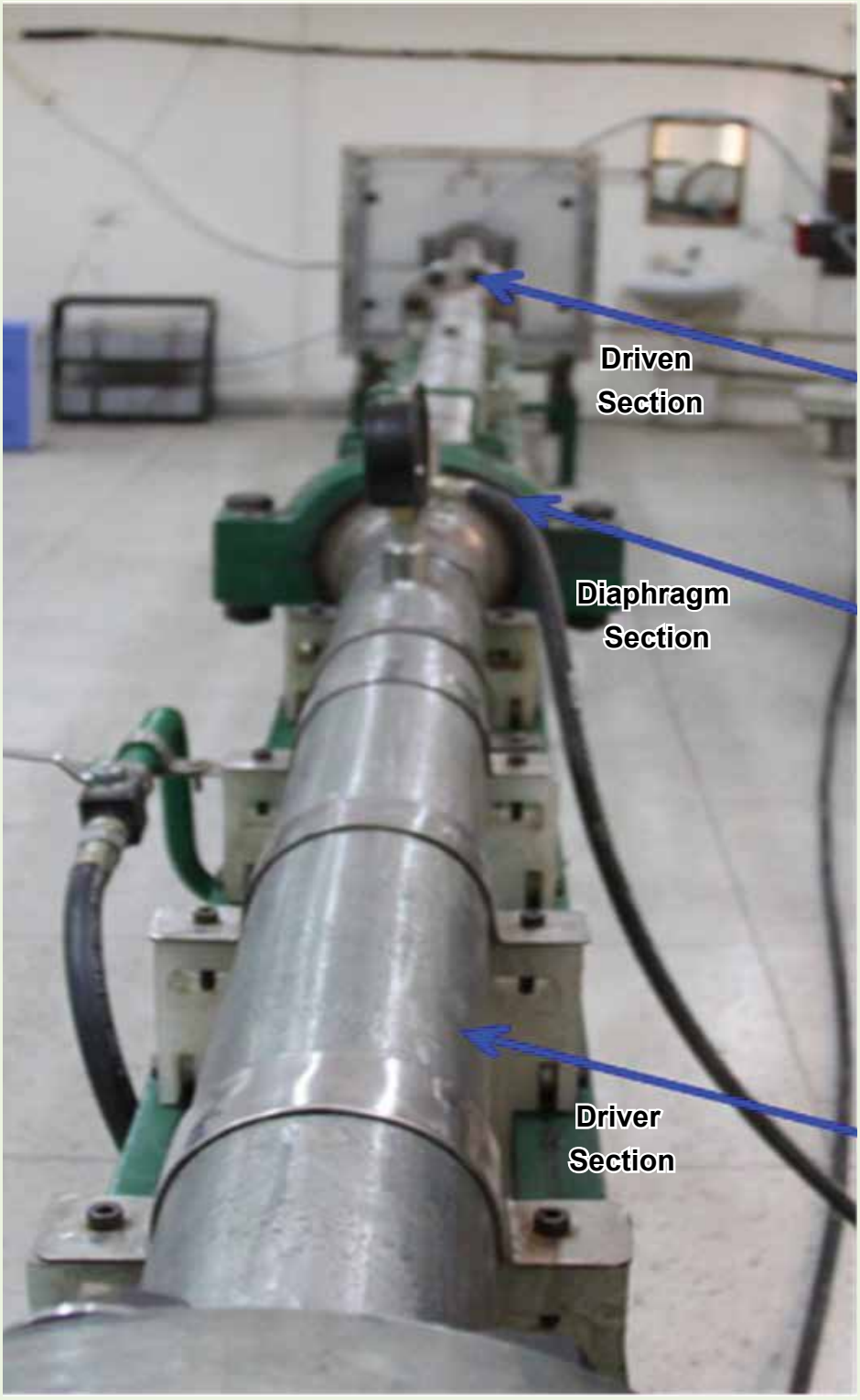
Packages After Bonfire Test

Shock Tube

Experimental studies of blast effects on structural elements are required for design and development of protective structures and defence platforms, which might be subjected to blast loads due to accidental explosion or deliberate attack. For this, it becomes necessity to simulate the blast loading conditions caused by an explosion accurately, safely and in a reproducible way.

Shock tubes are used to simulate blast waves to study their effects under laboratory conditions in a controlled and repeatable manner. Moreover, use of shock tubes for subjecting structural elements to shock wave loading is a safe, economical and reliable as compared to field testing with explosives. Testing of small scale panels of metals, concrete and composites against blast load is done in shock tubes.

Compression-driven shock tube facility of diameter 100 mm has been established at CFEES which can produce shock waves up to 2.5 Mach. It consists of two sections, one with high pressure called the driver section and the other with low pressure called driven section. The driver and driven sections are separated by a diaphragm. Diaphragm ruptures after a certain pressure in the driver section. After the rupture of the diaphragm, large difference in the pressure between the two regions causes a shock wave to run through the driver section. The shock wave produced in the driven section is used for testing of blast resistant materials and scaled down models of blast protective components/ structures.



Environment Safety Technologies

In-house Management of Bio-degradable Wastes

Huge quantity of solid bio-degradable waste is generated in DRDO labs and residential complexes. The management of this kind of waste has become a major challenge due to environmental concerns and in achieving nations' concerns on clean India. As per Central Pollution Control Board (CPCB) report (2005), Solid waste generated in India constitutes 40-60 per cent bio-degradable/compostable matter. These biodegradable wastes can be efficiently converted into a value added product, i.e., compost through composting technology, which is a low-cost and eco-friendly technology for bio-conversion of organic wastes. Compost produced in this way can be used for horticulture/gardening in the campus, which will help to develop a sustainable campus. To provide such eco-friendly solution a sustainable environmental management plan for in-house management of all kinds of biodegradable wastes has been prepared. Waste minimization, development of environmentally sound disposal technologies, including technologies to convert waste into wealth and recycling has been kept on priority. Food waste generated from wet canteen, garden waste generated from grass and leaves trimmings and paper waste generated at the lab is being handled at the laboratory level.

Process/Technology

For composting of the food waste and garden waste on site composting equipment, in-vessel composters and leaf composter have been installed. Approx. 15-20 kg segregated food waste generated at wet canteen is fed in in-vessel composters and garden waste is fed in leaf composters. A teaspoon of accelerator/microbe powder is mixed in 100 ml water and poured all over the waste daily and coco peat powder is spreaded all over the waste evenly. This waste is converted into compost after a process of 40-45 days. Leachate produced in the process is collected and used for plants after appropriate dilutions. Approximate 200 kg of compost is produced per batch to be utilized as manure for horticulture. Paper waste produced at lab is sent for recycling after shredding and recycled paper is taken for use in laboratory in return of waste paper.

Significance of Waste Disposal and Transformation

- Improves the efficiency of waste management systems
- Recovers recyclable materials for reuse
- The total quantity of generated wastes gets reduced and demand for land which is already scarce in cities for waste dumping is reduced.
- Emissions of green house gases can be prevented, reducing global warming
- Improves the aesthetic value of environment and reduces vector borne diseases
- Restores microbial population in soil and directly modifies the physical, chemical and biological properties of soil

Advantages of using Compost

- Compost has been identified as eco-friendly, safe and beneficial and an alternative to fertilizer to increase the soil fertility and crop production in organic farming by Ministry of Agriculture and Farmers Welfare, Govt. of India

Waste Management

TECHNOLOGY FOCUS
READERS' FEEDBACK

Your feedback is important to us for further improve the content and presentation of information. The editorial team requests you to kindly fill in the feedback form and give your level of satisfaction and newer aspects you would want to incorporate in the *Technology Focus*.

Rate the ***Technology Focus*** as a medium to present DRDO's technology and product developments?

Excellent ☐ Good ☐ Satisfactory ☐ Needs improvement ☐

How do you rate the quality of photographs in the ***Technology Focus***?

Excellent ☐ Good ☐ Satisfactory ☐ Needs improvement ☐

Optimal number of pages you would like for the ***Technology Focus***?

16 Pages ☐ 20 Pages ☐ 24 Pages ☐ 28 Pages ☐

Preferred medium of ***Technology Focus***?

Print ☐ Online (PDF) ☐ E-pub ☐ Video Magazine ☐

Whether magazine is delivered on time?

Yes ☐ No ☐

What should be the frequency of ***Technology Focus***?

Bimonthly ☐ Quarterly ☐ Half-yearly ☐

For updates on ***Technology Focus***, Kindly provide your e-mail id.

Suggestions, to further improve the ***Technology Focus*** ?

Name: Signature

Address:

- ◊ Composts are rich in macro and micronutrients and has been recommended as an ideal bio-fertilizer
- ◊ Improves the physical structure and natural fertility of soil
- ◊ Increases the water holding capacity of soil
- ◊ Decreases the external inputs as chemical fertilizers reducing soil and water pollution

CFEES model of waste management has also been demonstrated to Estate Managers of other Units of DRDO for transition in their respective laboratories through DCW&E.

E-waste Management in DRDO

E-waste has become one of the fastest growing waste streams of recent times. Electronic products are a complex mixture of several hundred tiny components, many of which contain hazardous chemicals. Most of the electronic devices contain toxic constituents in their components such as lead, cadmium, mercury, Polychlorinated Bi-phenyls (PCBs), brominated flame retardants, etc., which are a threat to human health and environment. Thus E-waste represents an emerging environmental problem and poses serious challenge to every sector of the economy. DRDO uses electrical and electronic materials for a myriad of its research and development activities, resulting in the generation of E-waste. CFEES has formulated 'Guidelines for E-waste management in DRDO' with an intent to provide an institutional framework to manage E-waste in an environmentally prudent manner and consistent with the existing national rules for E-waste management.

Salient Features

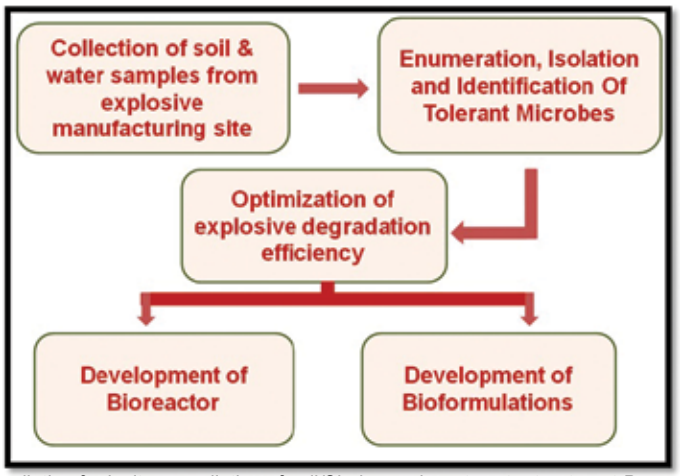
- ◊ Recommendations for E-waste handling in important stages of DRDO's functioning, viz., project formulation, procurement, consumption, final disposal and condemnation
- ◊ Stakeholder responsibilities and delegation of power with respect to E-waste management in DRDO
- ◊ Monitoring mechanism for ensuring compliance

Bioremediation Technology for treating explosive contaminated wastewater and soil

Effective environmental management is increasingly being ingrained as an important part of all defence activities. Facilities involved in manufacturing, processing and handling of explosives have resulted in contamination by high concentrations of toxic nitro organics in soil and water. These contaminants due to their recalcitrant nature pose a serious challenge for pollution control. Conventional treatment technologies such as activated carbon adsorption, alkaline hydrolysis, etc. have resulted in transfer of contaminants from one phase to another. Therefore it is essential to develop an eco-friendly technology for treating the waste water and contaminated soils of these facilities. Remediation by biological systems termed as bio-remediation has attracted worldwide attention due to its eco-friendly nature. CFEES has developed bio-formulations for *in situ* remediation of soil, sludge and sediments soil and bio-reactor for treating explosive contaminated wastewater.

Potential Applications

- ◊ Ordnance factories and DRDO laboratories manufacturing explosives
- ◊ Firing, testing and training ranges
- ◊ Unexploded ordnance
- ◊ Hazardous nitro-organics handling industrial sites



Bioremediation for insitu remediation of soil/Sludge and wastewater treatment-Process Steps

Water Mist Aerator for Water Conservation

The water mist aeratoris a single fluid nozzle with low flow rate. By using this aerator the water consumption in the household shall be reduced. Water mist aerator has application in domestic sector for water conservation. The water mist aerator have been designed and developed according to the standard faucets available in India. The water mist aerator is fixed to the standard faucets/taps. The broad specification of the water mist aerator is:

◊ Mode of operation: Mist and Jet mode

◊ Material of construction: SS 316L

◊ Flow rate: 300-1000 ml/min in mist mode: ≥1000 ml/ min in Jet mode

◊ Working pressure: 0.5-10 bar

◊ Droplet size: 300 microns (VMD)

◊ Water saving: Mist Mode 95% & Jet Mode 75% as compared to regular faucets

◊ Maintenance free, retrofits into existing tap without disturbing aesthetics

Testing Facility

Fire Safety Products – Test and Evaluation

CFEES, being a specialized lab in the areas of fire, explosive and environment safety, is recognized by Bureau of Indian Standard (BIS) as a specialized laboratory for "Testing of Fire Safety Products".

CFEES has the required competence, expertise and infrastructure for testing of fire safety products like dry chemical powder, fire-fighting fabric, Halon Gas, AFFF Foam, Fire-fighting hose, etc. Due to its unique charter and expertise, the lab receives samples from both government as well as private agencies for testing of various products and materials. To ensure effective and time bound test and evaluation activities, the complete sample testing process is controlled through a duly approved SOP. Testing is also planned and undertaken for special products being developed by private industries after taking necessary approval.

CFEES has extended its core expertise in the field of test and evaluation of various Fire Safety Products for over a decade, to enhance the quality and reliability of submitted products being used by Tri-Services, DPSUs other Govt. of India organizations and private industry.

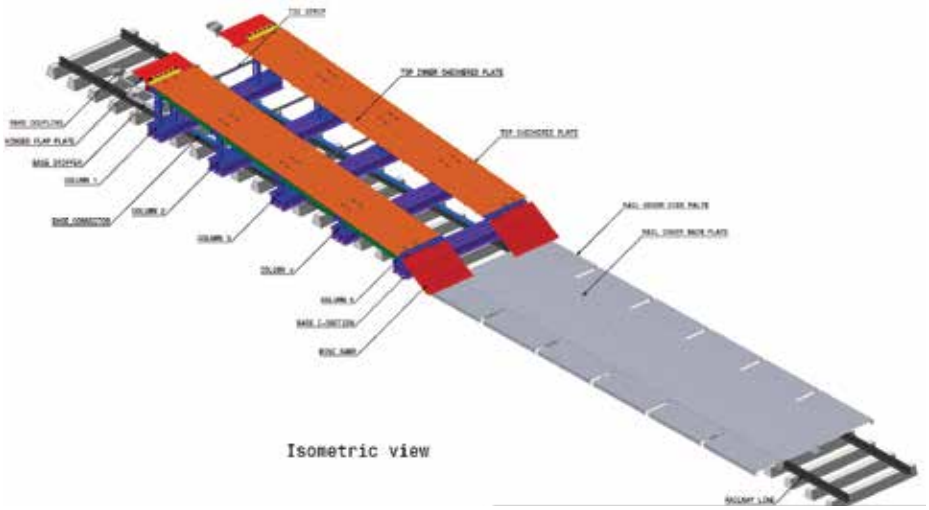
Mobile Metallic Ramp (MMR)

Armoured vehicles are incredibly useful in battle. But they are difficult to transport to remote locations (where many confrontations take place) because their loading and unloading is a tedious process. At the time of emergency/ war scenario, the combat vehicles like, tanks, BMP's are required to be transported from military station to the site of operation/battlefield. Every military station is having military siding at some nearby railway station. These military sidings are basically railway track dead ending at cemented ramps. This type of cemented ramps cannot be made in emergency due to the fact that making a branched railway track and a cemented ramp at the end of it is a time consuming job, which requires 30-40 days.

In view of this, Army has approached CFEES to design and develop a Modular and Portable Mobile Metallic Ramp (MMR) for A-class vehicles, which will help in reducing the mobilizing timings during an unscheduled and emergency loading/ unloading of armored vehicles in case of any action anywhere en-route.

As per the requirements, CFEES has designed and fabricated a modular and portable ramp in the year 2012-13 and the User trials have been carried out at army sites in the year 2017-18. The MMR assembly is comprised of around 120 main parts. The design has been validated by successful trials of more than 200 no. of passes of various armoured vehicles including T-90, BMP, ARV and other class-B vehicles .

The MMR has been handed over to Indian Army.



DESIDOC thanks Shri Amit Pasi, Sc 'E' of Centre for Fire Explosive & Environment Safety (CFEES) for bringing out this issue of *Technology Focus*.

डेसीडॉक द्वारा प्रकाशित

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