PROCEEDINGS
OF THE MARINE SAFETY COUNCIL

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Blame It On Combustion!

106 Year Old Captain Renews License

U.S. Department of Transportation
U.S. Coast Guard

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PROCEEDINGS
OF THE MARINE SAFETY COUNCIL

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features

Many people in the maritime industry work with or around potentially hazardous cargoes and are aware of the danger of accidental chemical reactions. Words like "fire," "explode," "deflagrate" and "detonate" become familiar to these workers through everyday use--yet, upon questioning, the meanings of such words may be somewhat unclear to them. Dr. Schneider has prepared a review of terms which tend to be used incorrectly in reference to various combustion incidents, and illustrates their differences through common occurrences familiar to all readers.

This year's Presidential Proclamation from Vol. 44, No. 161 of the Federal Register.

departments

cover

Last July, Captain Thomas A. Small renewed his license through the Coast Guard Marine Inspection Office in St. Ignace, Michigan. Commander Timothy G. McKinna also presented to the 106-year old skipper his original master's license, which had remained in the files throughout the years. More about this remarkable mariner is on page 171.

maritime sidelights

COAST GUARD SEEKS MERCHANT MARINE OFFICERS

The U.S. Coast Guard is seeking qualified licensed merchant marine officers to join the service as lieutenants or lieutenants (junior grade) to work in marine safety and related fields.

Merchant marine officers have been commissioned in the Coast Guard to work in marine safety related fields since 1946, when the Bureau of Marine Inspection and Navigation became a part of the Coast Guard.

Expanded marine safety responsibilities and recent reductions in the number of officer applicants have prompted the Coast Guard to revise requirements for the commissions.

Revised requirements for commission as a lieutenant are:

*be under 38 years of age;

*hold one of the following licenses: Chief Mate (unlimited), oceans or coastwise; Master and First Class Pilot (Great Lakes); First Assistant Engineer (any horsepower), or any higher rated license;

*three or more years service as licensed officer on board U.S. vessels: (at least six months service must have been as Chief Mate, First Assistant Engineer, or higher).

Lieutenant (junior grade) requirements are:

*be under 32 years of age;

*hold one of the following licenses: Second Mate (unlimited), oceans or coastwise; First Class Pilot (unlimited), Great Lakes; Second Assistant Engineer (any horsepower), or any higher license;

*two or more years service as licensed officer on board U.S. vessels.

The application process no longer requires a professional examination. Applicants must complete officer qualification and English examinations only.

Interested persons should call or write: Commandant (G-PMR), U.S. Coast Guard, Washington, DC 20590, telephone 202-426-1370 or contact their nearest Coast Guard Marine Safety/Inspection Office or Coast Guard District Military Procurement Officer.

DON'T RELY ON "FILL IN THE BLANK" TRANSFER PROCEDURES

The Port Safety Inspectors at MSO Portland, Oregon have observed a change in the nature of Pollution Prevention Regulation violations during the course of the boardings of foreign flag vessels.

Previously the nature of the violations mainly were a lack of any written oil transfer procedures on these vessels. Recently, however, many agents are leaving "fill in the blank" type of procedures aboard ships which intend to take on fuel or diesel oil. The use of these fill-in procedures has resulted in violations for incomplete procedures (33 CFR 155.750). The ship's personnel are not preparing proper oil transfer procedures from these handouts. In fact, the forms themselves are not being completed prior to taking on oil, unless we observe it and explain what must be done to bring the vessel into compliance. The basic feeling seems to be that since the ship's agent left the handout, the ship is in compliance and can therefore bunker.

Another problem area encountered is that the procedures are not being translated and written in the language of the crew. This is necessary, unless a majority of the crew can read and understand English (33 CFR 155.740).

A third problem is a failure to maintain the required written records of the names of each designated person-in-charge of oil transfer operations (NOT of each and every person involved) and the dates and results of the most recent tests and inspections of the oil transfer system as outlined in 33 CFR 156.170 (33 CFR 155.820).

The number of violations for these three problem areas could easily be reduced if the agents would insure that the ship's crew understands what needs to be done with these handouts, and then certify that the ship is in actual compliance prior to the ship bunkering.

If you have any questions about the application of any of the Pollution Prevention Regulations of 33 Code of Federal Regulations, Parts 155 and 156, call your local Coast Guard Captain of the Port (COTP) or contact Pollution Prevention and Enforcement (G-WEP-3/73), U.S. Coast Guard Headquarters, Washington, DC 20590; (202)426-1477.

(Reprinted from the Portland, Oregon COTP *Marine Safety Newsletter*)

INTERNATIONAL HYPOTHERMIA CONFERENCE

For the first time both hypothermia research and training in the treatment of hypothermia victims will be the focus of an international conference and workshop to be held January 9-13, 1980 at the University of Rhode Island, Kingston.

Hypothermia is the cooling of the internal body temperature down to the point where death occurs. It is considered a major cause of death in cold water drowning cases, in the wintertime deaths of elderly persons and small children, and in deaths of people exposed over several hours to low air temperatures.

From January 9-11, participants from medical and nursing fields, university research, government service and rescue organizations will gather to hear the latest results of research into hypothermia. Starting the afternoon of January 11 there will be an educational workshop in which the latest techniques for treatment of hypothermia victims will be presented.

Continued on next page.....

Sponsors of the conference include the University of Rhode Island, the National Sea Grant Program—National Oceanic and Atmospheric Administration, the U.S. Coast Guard, the National Red Cross, the Undersea Medical Society, the R.I. Boating Council and the Underwater Society of America.

Conference chairman Neil W. Ross, specialist with the URI Marine Advisory Service, explained that "The conference is intended to bring together the world's leading experts in hypothermia research and treatment in order to spread the knowledge these people have gained to as wide an audience as possible. In addition, we hope they will identify needed areas of research and establish national standards for hypothermia treatment."

Ross said that the conference was the result of a recent awareness that hypothermia is a leading cause of many cold-related deaths and that there is a need for change in cold-water survival education and in traditional treatment methods for hypothermia victims. "Dr. Martin Nemiroff of the University of Michigan has demonstrated the need for changes in medical treatment with his successful revival of people who have been submerged under cold water for long periods of time. There has been a growing realization in the medical community that low thermostat settings in the homes of elderly persons has contributed to the onset of hypothermia and eventual death," he added.

The 2½-day technical conference will be followed by a weekend workshop which will train top level trainers and educators in hypothermia prevention and medical treatment. the program will include the latest information presented at the conference, lectures, demonstrations, in-water experience for treatment of cold-water victims and instruction in training techniques. Enrollment in the workshop will be limited to 200 persons.

Both the conference and the workshop are an outgrowth of favorable reactions to a regional training workshop in hypothermia and cold-water survival sponsored by the R.I. Boating Council at the University of Rhode Island in January 1978. That program began as a one-state training program but grew to include training of personnel from 11 states.

More information about the conference and workshop can be obtained by writing: International Hypothermia Conference, University of Rhode Island Marine Advisory Service, Narragansett, RI 02882.

TANKER OFFICER TRAINING COURSE

The California Maritime Academy's Adult Maritime Education Department is presenting a basic course for tanker officers utilizing the academy's recently completed tanker simulator.

The 5-day course will be repeated October 8, November 5, and December 3.

The tanker simulator was developed by the Cal Maritime faculty and Dynacon Corporation of Concord, California at a cost of more than a quarter of a million dollars. According to Rear Admiral J. P. Rizza, President of the academy, the highly sophisticated electronic console is capable of simulating the actual loading, discharging, and ballasting of a tanker ship of any size, as well as any configuration of piping in shoreside facilities.

This course is designed for junior tanker officers who need to gain experience on a console-controlled cargo loading/discharging/ballasting system. Included in the course will be: Ship and Console--introduction and comparisons with other ships and systems; Stability and Trim--transverse and longitudinal, free-surface effect, stress of ships, calculating trim and stress; Cargo Pumps and Related Equipment--reciprocating, rotary, centrifugal pumps, etc.; Tank Cleaning--Load on Top--Crude Washing and Ballasting; Inert Gas Systems; Safety and Government Regulations; Problems--actual loading, discharging, and ballasting.

For further information, contact the California Maritime Academy, AME Department, P.O. Box 1392, Vallejo, CA 94590, 707-644-5601.

NFPA INFO ON FIRE EXTINGUISHERS

Most businesses and industries count on portable fire extinguishers as their first line of defense against fire emergencies. But are the extinguishers appropriate for the kinds of hazards against which they are likely to be used? Are they easily accessible? Do employees know how to use them?

The National Fire Protection Association (NFPA) addresses these issues in a new sound/slide presentation entitled "Portable Fire Extinguishers: Selection, Placement and Use" (SL-47). This program, designed to encourage planning for fire emergencies, examines the kinds of fire hazards likely to be encountered in business and industrial settings and suggests the types of extinguishers most appropriate for dealing with specific hazards. Rules for placement of extinguishers are examined as well as programs for training employees in proper extinguisher use.

NFPA also has a new slide program designed to introduce fire fighters to various types of foam extinguishing agents, including protein, fluoroprotein, high expansion, alcohol, and aqueous film forming foam. Entitled "Fire Fighting Foam" (SL-46), the presentation demonstrates how the various foam agents work, their properties, the types and characteristics of flammable liquid fires requiring foam extinguishment, and proper utilization of foam. With flammable and combustible liquids in increased use, fires requiring foam extinguishment are more frequent.

Designed for fire service as well as industrial fire safety training, the program emphasizes coordination between local fire departments and industrial brigades.

For further information on these or other NFPA fire safety programs, contact NFPA Publications Dept., 470 Atlantic Ave., Boston, MA 02210.

key notes

Any questions regarding regulatory dockets or companies and individuals wishing to speak at public hearings should notify Captain P. J. Danahy **at our new address:** (G-CMC/TP24), U.S. Coast Guard Headquarters, 2100 Second St. SW, Washington, DC 20590; (202)426-1477.

* * *

QUALIFICATIONS OF THE PERSON IN CHARGE OF OIL TRANSFER OPERATIONS, TANKERMAN REQUIREMENTS CGD 74-44, 74-44a

These regulations will redefine and establish qualifying criteria for certifying individuals engaged in the carriage and transfer of dangerous cargoes in bulk.

It has been found that most pollution incidents are the result of personnel error; consequently, the minimum qualifications of persons involved in handling polluting substances should be specified.

As stated in the last issue, these projects have been withdrawn (44 FR 25243). New NPRM's which were anticipated in June have been delayed and are now scheduled for publication later this year under new Coast Guard docket numbers 79-116 and 79-116a.

REVISION OF ELECTRICAL REGULATIONS CGD 74-125

This regulation will constitute a general revision and updating of the electrical regulations to conform with latest technology. It will include steering requirements for vessels other than tank vessels.

This revision is occurring because industrial standards for electrical engineering have changed in the past few years, and the regulations must be brought up to date to reflect current industry practices.

An initial NPRM was published on June 27, 1977 (42 FR 32700). A supplemental NPRM will be issued late in 1979.

STANDARDS FOR NEW SELF-PROPELLED VESSELS CARRYING BULK LIQUEFIED GASES CGD 74-289

These regulations adopt the Intergovernmental Maritime Consultative Organization (IMCO) Resolution, the Code for Construction and Equipment of Ships Carrying Liquefied Gas in Bulk.

The increased use of liquefied gases for energy sources has produced a dramatic increase in the manufacture and use of vessels designed for the cargo. Due to the unusual and unique hazards associated with liquefied gases, these vessels must be addressed in regulations specially tailored to their unique situation.

The final rule was published May 3, 1979 (44 FR 25986). Copies of this rule and its supporting documents may be obtained by writing or calling the Marine Safety Council at the address/telephone number given at the beginning of the Keynotes section.

NEW TANK BARGE CONSTRUCTION CGD 75-083 UPGRADE OF EXISTING TANK BARGE CONSTRUCTION CGD 75-083a

This action is comprised of two regulatory projects centered on tank barge construction standards. These projects were the result of a Presidential initiative of March 17, 1977, directing a study of the tank barge pollution problem. One project will address new barge construction while the other will pertain to existing barges. Regulatory documents for both will be published at the same time and joint public hearings will be held.

In July 1977, the Coast Guard began a reexamination of the tank barge construction standards. It was determined that new construction would be treated separately from existing barges. An advanced notice of proposed rulemaking (ANPRM) was then issued to gather additional data and assess impacts related to existing barges.

The new NPRM on tank barge construction, withdrawing the prior NPRM and the ANPRM for existing tank barges, was published as part VI of the June 14, 1979 Federal Register (44 FR 34440 and 44 FR 34443, respectively).

Public hearings were held on the dockets as follows: August 2, 1979, Washington, DC; August 15, 1979, Seattle, WA; August 23, 1979, New Orleans, LA; September 5, 1979, Washington, DC; and September 7, 1979, St. Louis, MO. The comments given at the hearings have been incorporated in the docket and are currently being reviewed by the project managers.

Anyone wishing to obtain copies of the rulemaking may do so by contacting Capt. P. J. Danahy, Marine Safety Council **at our new address** (telephone number has not changed) which is given at the beginning of the Keynotes section.

POLLUTION PREVENTION, VESSELS AND OIL TRANSFER REGULATIONS CGD 75-124a

This regulation would reduce accidental or intentional discharge of oil or oily wastes during vessel operations.

The basis of this regulation is threefold. First, there is the need to reduce the number and incidence of oil spills. Second, this regulation will help to clarify the existing rules. Finally, this regulation covers the additional requirement for oil-water separators under the 1973 International Convention for the Prevention of Pollution from Ships.

The NPRM was published on June 27, 1977 (42 FR 32670). A supplemental NPRM was published October 27, 1977 (42 FR 56625). As stated in the August issue, the draft of the final rule is under its legal review prior to publication.

Continued on next page.....

DESIGN AND APPROVAL REQUIREMENTS FOR OIL POLLUTION PREVENTION EQUIPMENT CGD 76-088a

These regulations set out specifications and procedures for approving oil-water separators, cargo monitors, bilge monitors and bilge alarms for use on merchant vessels. They are based upon international design and test specifications adopted by the International Maritime Consultative Organization (IMCO) as Resolution A-393X, and provide standards for equipment that is representative of the best technology presently available.

The final rule, published in the September 13, 1979 Federal Register (citation number not known as we go to press), requires that performance testing of prospective equipment must be done by one of the independent testing laboratories designated by the Commandant (G-MMT). The following laboratories have received authorization to commence testing:

Underwriters Laboratories
Tampa, Florida, USA

National Sanitation Foundation
Ann Arbor, Michigan, USA

University of New Castle
New Castle Upon Tyne, UK

OFFSHORE OIL POLLUTION FUND CGD 77-055

This document established procedural rules concerning administration and operation of the fund, including liability limits for certain facilities, financial responsibility factors, damage claim settlement procedures, et. al.

This regulation was passed to create procedures for prompt settlement of claims arising from damage caused by oil pollution.

The final rule of this docket was published March 19, 1979 (44 FR 16860).

The following three regulations make up the Tanker Safety and Pollution Prevention (TSPP) Regulations. Public hearings have been held on the package, comments were requested and 541 have been received. Final rules on this package are currently being written. A notice of delay in publishing the final regulations was published in the June 7, 1979 Federal Register (43 FR 32713). Final rules are anticipated in the fall of 1979.

INERT GAS SYSTEM CGD 77-057

This regulation would require certain oil tankers of 20,000 deadweight tons and over to be fitted with inert gas systems.

As part of the President's initiatives to reduce marine pollution, this regulation will reduce the possibility of in-tank explosions which have been the cause of some pollution incidents.

The Inflationary Impact Statement for this regulation was completed in May 1977. An NPRM was published May 16, 1977 (42 FR 24874). An ANPRM was published February 12, 1979 (44 FR 8984); 136 comments have been received on the docket.

SEGREGATED BALLAST AND TANK CLEANING REGULATIONS GCD 77-058(b), (c) and (d)

This four-part regulation was initiated when President Carter directed the Secretary of Transportation to issue new rules for oil tanker standards, which were to include segregated ballast on all tankers and double bottoms on all new tankers which call at American ports. The provisions of these proposed regulations have been changed by the February 1978 Intergovernmental Maritime Consultative Organization (IMCO) Conference to include Crude Oil Washing (COW) and Clean Ballast Tanks (CBT).

The NPRM was published May 16, 1977 (42 FR 24868). As a result of the IMCO Tanker and Pollution Prevention Conference of February 1978, a new NPRM will be issued. This rulemaking was also mandated by the Port and Tanker Safety Act of 1978. An NPRM was published February 12, 1979 (44 FR 8984); 265 comments have been received on the docket.

STEERING GEAR DESIGN STANDARDS TO PROVIDE REDUNDANCY CGD 77-063

As part of the President's initiatives to reduce pollution, this regulation is needed to help reduce the possibility of a marine collision due to a loss of steering.

An NPRM was published May 16, 1977 (42 FR 24869). As a result of the IMCO Tanker Safety and Pollution Prevention Conference of February 1978, a new NPRM was issued on February 12, 1979 (44 FR 8984); 138 comments have been received on the docket.

CONSTRUCTION AND EQUIPMENT EXISTING SELF-PROPELLED VESSELS CARRYING BULK LIQUEFIED GASES CGD 77-069

These regulations would amend the current ones to include the substantive requirements of the "Code for Existing Ships Carrying Liquefied Gases in Bulk," adopted by the Intergovernmental Maritime Consultative Organization (IMCO). The use of liquefied gas has increased, as have the problems associated with it. Due to its unique properties and the dangers associated with them, new regulations are being drafted. The environmental impact statement and regulatory analysis were completed in February 1979 and an NPRM on these regulations is anticipated in November of this year.

LICENSING OF PILOTS CGD 77-084

This regulation takes into account the problems caused by increased ship size and unusual

Continued on next page.....

maneuvering characteristics. The proposal would require recency of service for each route upon which a pilot is authorized to serve, licensing with tonnage limitations commensurate with pilot experience, and consideration of ship-handling simulator training for pilots of very large vessels. A regulatory analysis and work plan were completed in October 1978. An NPRM is expected in October 1979.

REVISION OF 46 CFR 157.20-5 DIVISION INTO THREE WATCH REGULATION
CGD 78-037

This revision would require an adjustment in vessel manning requirements, to bring them in line with current legislation. It would change the requirements which identify personnel who must be used on the three watches and personnel who may be employed in a day working status. An NPRM is scheduled to be published on this docket in October 1979.

TANK VESSEL OPERATIONS REGULATIONS, PUGET SOUND
CGD 78-041

This regulation governs the operation of tank vessels in the Puget Sound area. It was initiated to reduce the possibility of environmental harm resulting from oil spills in Puget Sound. This is to be accomplished by governing the operation of tankers and reducing the risk of collision or grounding.

Former Secretary of Transportation Brock Adams signed a 180-day Interim Rule on March 14, 1978 prohibiting entry of oil tankers in excess of 125,000 deadweight tons in Puget Sound; this appeared in the Federal Register of March 23, 1978 (43 FR 12257). An ANPRM was published March 27, 1978 (43 FR 12840). An extension of the interim rule was published in the Federal Register in order to allow the Coast Guard adequate time to complete this rulemaking.

The public hearings scheduled June 11 and 12 in Seattle, Washington, June 13 in Mt. Vernon, Washington, and June 14 in Port Angeles, Washington have been completed and all the comments received have been entered in the docket files for consideration. The extension of the interim navigation rule was published June 21, 1979 (44 FR 36174). This extension was effective July 1 and will be in effect until the Coast Guard prints notice of its cancellation. Copies of documents or the transcripts of the hearings may be obtained by writing to the Marine Safety Council.

EIGHT-HOUR DAY VOLUNTARY OVERTIME
CGD 78-146

This docket is a review of the Eight Hour Day, Voluntary Overtime regulation in 46 CFR 157.20-10, which states that no licensed officer should be required to be on duty more than eight hours per day except in extraordinary circumstances. Existing regulations, however, do not address overtime or consider any possible "fatigue factor." Recent Coast Guard studies have shown that this factor has a profound effect on reaction time and judgement, therefore the regulation is currently being reviewed. An ANPRM is expected in late October 1979.

PERSONNEL JOB SAFETY REQUIREMENTS FOR FIXED INSTALLATIONS ON THE OUTER CONTINENTAL SHELF
CGD 79-077

This regulation is concerned with the health and safety requirements for installations and vessels engaged in oil field exploration and development. This action was mandated by pending Outer Continental Shelf legislation. It will provide more comprehensive protection for personnel employed in vessels and installations in the oil trade. the work plan received by the Marine Safety Council (MSC) in early July calls for an NPRM in October 1979.

PERSONNEL AND MANNING STANDARDS FOR FOREIGN VESSELS
CGD 79-081

This regulation, deemed necessary to reduce the probability of oil spills, would establish minimum manning levels for foreign tank vessels operating in U.S. navigable waters. It would also establish procedures for the verification of training, qualification and watchkeeping standards. An NPRM is expected on the docket in late October 1979.

* * *

A complete listing of all Coast Guard regulations, both "significant" and "non-significant," appears in the Department of Transportation Semi-Annual Regulations Agenda and Review List which was published in the Monday, August 27, 1979 Federal Register (44 FR 50140).

Blame It On Combustion

. . . but choose your words with care!

A. L. Schneider, Sc.D.
U.S. Coast Guard Headquarters
Washington, DC

The opinions or assertions contained herein are the private ones of the writer and are not to be construed as official or reflecting the views of the Commandant or the Coast Guard at large.

How many times have you heard someone say, "that will detonate" or "don't worry, this cannot explode"? If you work with hazardous cargoes, words like "fire," "explode," "deflagrate," and "detonate" may be part of your everyday vocabulary. Do you really know what these words mean? Sometimes, through common usage, their meanings seem to blur or overlap. Yet each of these words has a different meaning.

What is going on chemically and physically during a fire, explosion, deflagration or detonation? In virtually all accidents where large amounts of energy are released, the energy comes from *combustion*. Combustion occurs when oxygen in the atmosphere combines or reacts with a fuel, usually a hydrocarbon such as natural gas, heating oil, or gasoline. The carbon and hydrogen in these fuels react with the oxygen in the air--*combust*--and form carbon dioxide and water in addition to releasing large amounts of energy.

Combustion and a similar term, *burning*, both include fire, explosion, deflagration, and detonation. The various forms of energy produced during burning--heat, light, shock waves--come from the fact that there is more energy in the gasoline and oxygen that we started with than there is in the water and carbon dioxide which are produced by combustion. In the transition from one to the other, energy is given off. Think how many ways this energy is used when burning is controlled--heating a house, making steel, driving a car. The problem comes when this energy is released in ways that are not controlled.

We need to define the terms used to describe the way in which the energy is released. *Fire* is the non-technical, everyday word for a combustion process that occurs without overpressures. When the air pressure increases beyond normal atmospheric pressure, overpressure is said to have occurred. Overpressures happen when burning is so rapid that the nearby air pressure is increased, knocking down people and buildings, just as strong winds do. Hurricanes, for example, do much of their damage through overpressure. Curiously, people can withstand greater overpressures than buildings. More injuries to people are caused by objects striking them or by people flying through the air and hitting a solid object, rather than through direct contact with a pressure wave. This is not to suggest that fires are not dangerous, but only that the most violent effects of a combustion process, overpressures, are not present.

Gasoline burning on water - a fire.

Deflagration and *detonation* are technical terms. What distinguishes one from the other is the speed of the flame front through the burning fuel-air mixture. The speed of sound is the maximum speed for any chemical reaction, including combustion. This speed varies with temperature and pressure; most importantly, the higher the temperature, the higher the speed. If the speed of the flame is the same as the speed of sound as measured at the conditions of the flame front, the flame is a detonation. If it is below the speed of sound, it is a deflagration. Since the temperature and pressure of the flame front are different from that of, say, normal room temperature and pressure, the speed of sound at the flame front is different from the speed of sound at room temperature and pressure. For example, an airplane flying at the speed of sound close to the ground is flying faster than one high up in the sky flying at the speed of sound appropriate to the air temperature and pressure at that altitude. This is why people often say that the flame velocity is twice the speed of sound. They really mean that the flame speed is twice the speed of sound at room temperature and pressure. Again, if the flame speed is subsonic it is a deflagration, and if it is sonic it is a detonation. Be suspicious if someone says the flame speed is supersonic! Just as the speed of light is the upper limit on all velocities, the speed of sound is the upper limit of the naturally occurring movement of air.

These two kinds of combustion, deflagration and detonation, are very different. In a deflagration, speeds range from virtually zero to close to the speed of sound; in a detonation, flame speeds are always at the speed of sound. The faster the flame speed, the greater the overpressure and therefore the greater the potential destructiveness of the burning. What complicates the issue is that fast deflagrations can produce overpressures which, while not as high as in an actual detonation, are appreciable and could injure people and damage buildings. If it is you or your property that is harmed by a shock wave, it doesn't matter much whether it was due to a detonation or a deflagration!

In describing an accidentally produced combustion, be sure to use the term detonation only if you know that all the requirements have been met. Detailed investigation is usually required before you can say a detonation has occurred. Otherwise, merely say that an explosion occurred.

Explosion is the everyday word that bridges the gap between deflagration and detonation. This is not a technical term and so does not have an exact, technical meaning but it almost always refers to combustion events that produce significant, damaging overpressures. Explosions include all detonations and the strongest of the deflagrations, but are different from fires, which never produce overpressures. All things being equal, an explosion is worse than a fire.

How a combustion occurs is as important as how much energy is given off. A pound of gasoline will give off the same amount of energy whether it deflagrates or detonates. The effects on people and property are much different, however, and that is what really counts. Consider that coal piled on the ground is "burning" (oxidizing), like steel does, and releasing energy at a very low rate. Coal burning in a furnace gives off heat but no shock wave. Coal dust in a mine can detonate, doing massive damage. Although the same energy is released by each pound of coal reacting in the coal pile as by each pound of coal dust, the detonating coal dust does much more damage. Clearly, the detonation of a few pounds of coal dust is more dangerous then the "burning" of a ton of coal outside on the ground.

The marine community is more concerned with the effects from liquid hydrocarbon releases than with dusts. Yet, it is not the liquid itself that burns but rather the vapors from the liquid. Damage during accidental cargo releases can be very severe. Clouds of hydrocarbon gases--liquefied natural gas (LNG) vapor, liquefied petroleum gas (LPG) vapor, gasoline vapor--can form and mix with air. This mixing is important, because without oxygen no combustion can occur. For this reason, liquid fuels do not burn; they must first be vaporized, then mixed with oxygen. Solid high explosives can detonate in a powerful fashion without vaporization, either because the chemical reaction does not require oxygen or because there is oxygen within the solid explosive itself. Since all hydrocarbon fuels give off their energy through

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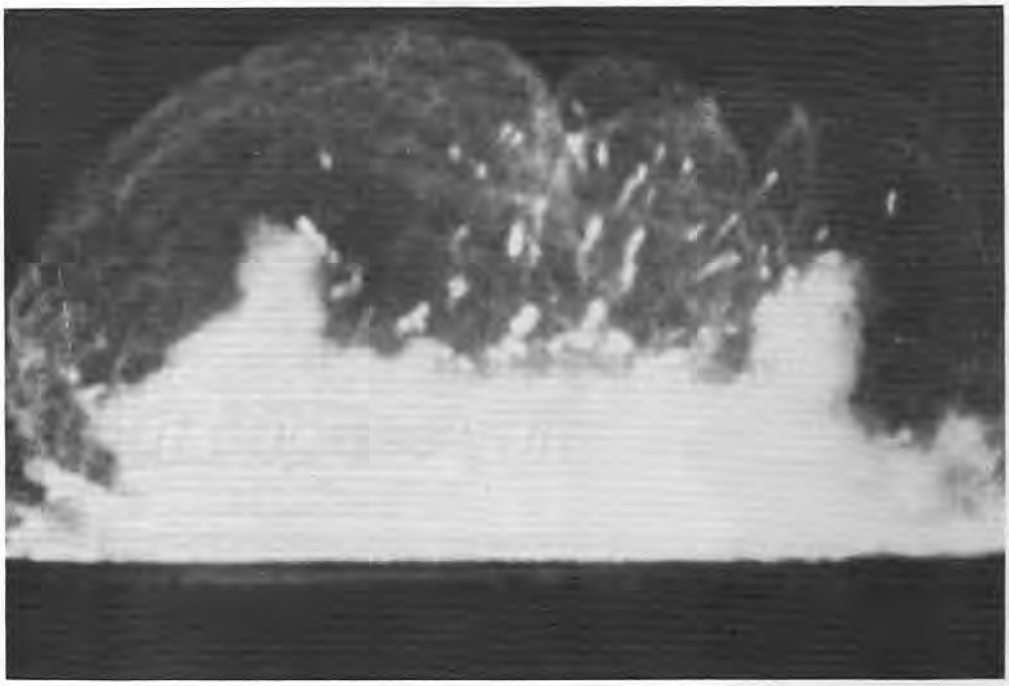


High speed photograph of USCG test to determine whether a deflagration can become a detonation. A methane-air mixture is contained within a large polyethylene hemisphere where a high energy ignition source initiates the burning.

combustion with air, they must be intimately mixed with air before burning is possible. This is why the flame on a natural gas burner cannot travel up the natural gas pipeline--oxygen is not available in the pipe, so the flame is stabilized at the mouth of the pipe. If the velocity of the fuel is increased, the flame becomes longer. In fact, if the velocity of the gas is high enough, the flame will detach itself from the burner. The flame would then be called a diffusion flame, the flame speed being limited by the rate of air mixing (diffusing) into the fuel. Remember the movie about the destruction of the dirigible Hindenburg? The vessel's hydrogen bags caught fire and burned in a few seconds. Since the bags contained only fuel, air had to mix with the hydrogen before burning was possible. This diffusion flame was slow enough that no overpressures were observed. Had the fuel been premixed, the flame speed would have been much faster, there would have been overpressures, and the loss of life probably greater. Consider a large spill of LNG onto water. If it is immediately ignited, it will produce a very large fire. The boiling LNG will be burned as fast as it can mix with air. No detonation is possible because the flame cannot move faster than air can diffuse into the fuel. The fire, of course, is very large, very intense, and quite dangerous, but much less so than if it were a detonation.

Again, consider the natural gas stove. If the burner is not lit, the gas will escape into the room and mix with air. In the case of natural gas, if there is less than 5 percent gas by volume in the fuel-air mixture, combustion can not occur; it is too lean to burn. Similarly, above 15 percent, the mixture is too rich to burn. If the mixture's composition were to lie between 5 percent and 15 percent (the flammability limits), burning follows as quickly as the flame can move through the mixture. This speed is called the flame velocity and applies to premixed fuels, that is, fuels which are already mixed with air. This flame velocity is almost always faster than diffusion flame speeds; however, premixed flame speeds vary depending on the temperature, pressure, mixture composition, and even whether the flame moves through the cloud horizontally or vertically. The fastest velocities occur when the mixture composition is neither too rich nor too lean. For natural gas, this composition is 10 percent, where there is enough oxygen to completely burn the fuel without any oxygen or fuel left over. If there is 5 to 10 percent fuel, there will be some excess air left over, but all the fuel will burn. If there is 10 to 15 percent fuel, some fuel will be left over because the oxygen will be consumed before all of the fuel is burned. The remaining fuel will burn in a diffusion flame as more air slowly mixes with the excess fuel. The fuel-air ratio is always important in combustion. Think how important the fuel-air ratio is to your car's engine.

Generally, premixed flames are more dangerous than diffusion flames. You can turn on all the burners on your gas stove and leave them on all day--nothing will happen, except your house will get warm. Blow out these slow-burning diffusion flames but do not turn off the gas flow. Let the house fill with about 10 percent gas and 90 percent air and strike a match. The flame speeds through the mixture, accelerating due to the enclosing walls. *Confinement*, or walls, can

greatly increase the flame speed; the faster the flame, the higher the overpressure. If you are unlucky, and if the conditions are just right, the overpressure can knock down your house. The exact details of how the combustion happens is as important as how much fuel there is. The faster the energy is released, the more destructive the burning will be.

Now if that large accidental LNG spill discussed earlier did not ignite, it would boil and form a vapor cloud. As the cloud drifts downwind, it mixes with air. If the cloud is ignited early, when most of it is above 15 percent fuel, there will be a diffusion flame. If the cloud is ignited late, when the fuel concentration has fallen below 5 percent, there will not be any combustion at all. In between, when the cloud is premixed, there is potential for accelerating flames with damaging overpressures.

If a vapor cloud deflagration accelerates to detonation the effects are much worse. A deflagrating vapor cloud will almost certainly kill anyone inside it, but will not necessarily kill people outside. The heat will be dangerous to people and property, but the overpressures are likely to be small. If the overpressures are large, particularly if the vapor cloud detonates, the pressure wave will kill and injure people at some distance away from the cloud. Property, too, will be damaged or destroyed at a distance from the cloud. In accidents involving liquefied petroleum gas (LPG) clouds there have been unconfined detonations. Confinement makes detonations more likely. LNG can detonate in a confined area, but can it detonate without confinement? This is important. Consider

Continued on next page.....

Aftermath of a natural gas burning - an explosion (photo courtesy of National Transportation Safety Board).

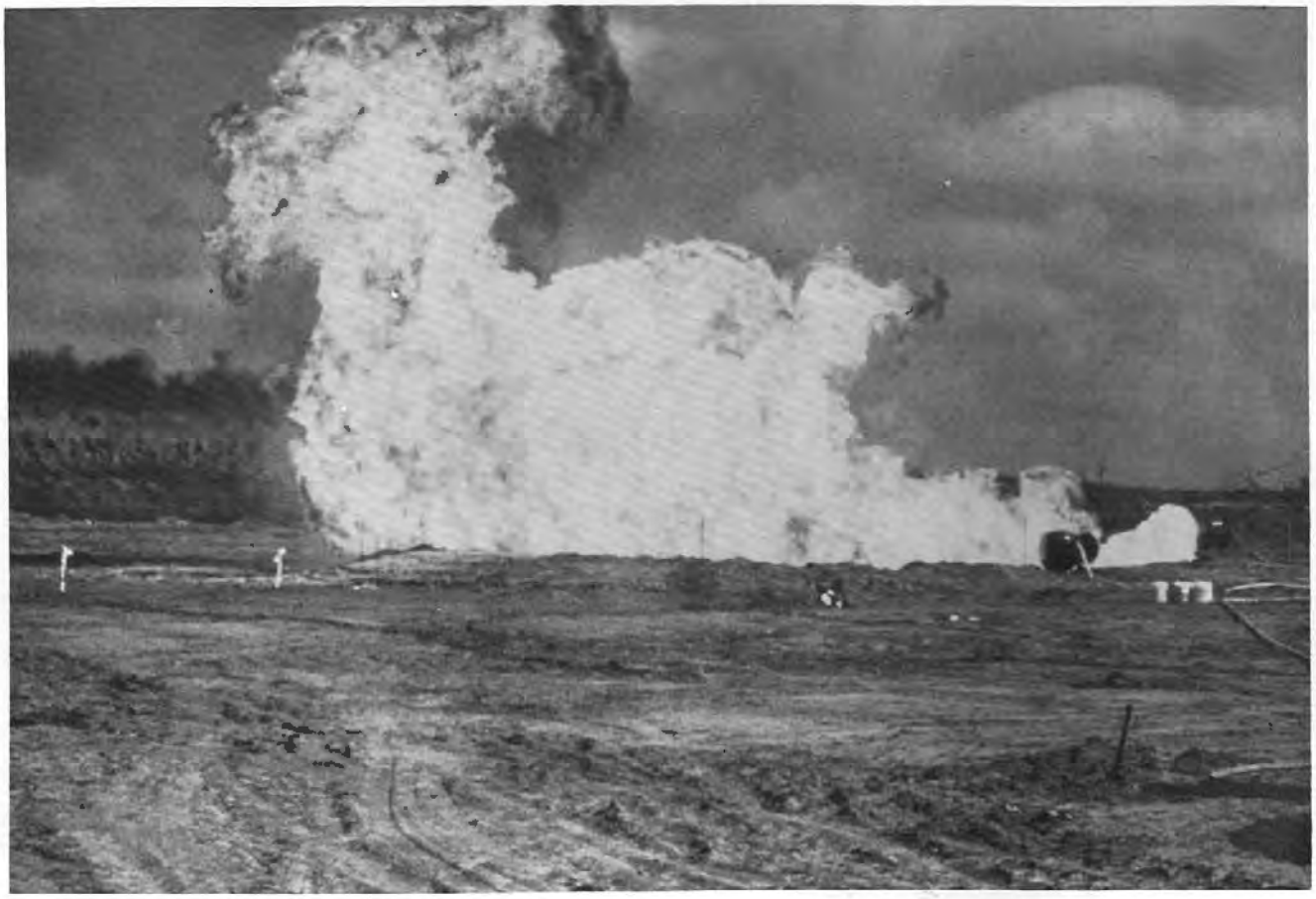
other gases that can detonate in the air. Typically, they have the blasting power of from 5 to 15 times their fuel weight in TNT. Since in accidental cloud detonations only about 10 percent of the fuel actually detonates (remember that only that part of the cloud within the flammable limits can detonate), one pound of LNG should have, at the most, an effective blasting power of from 0.5 to 1.5 pounds of TNT. Imagine a 125,000 m^3 LNG carrier with 25,000 m^3 of LNG in each tank, or roughly 10,000 tons per tank. This, if released and detonated, could have the effect of 5,000 to 15,000 tons of TNT.

The big "if" is whether LNG can detonate--and the answer is that it almost certainly cannot. There have been no accidents which have led to unconfined LNG vapor cloud detonations. Some natural gas pipeline accidents have given rise to severe vapor cloud deflagrations, but not to detonations. To determine experimentally whether detonations are possible, the Coast Guard has conducted a series of large-scale tests. The results show that it is difficult, if not impossible, to detonate unconfined vapor clouds made from commercial types of LNG, even using very large quantities of high explosives as the "match." Of course, it is never possible to prove a negative--that LNG vapors will not detonate--because there is an infinite number of combinations of test conditions. Most experts believe, though, that LNG will not detonate.

In conclusion, the two most important ideas in this discussion are: first, when dealing with a combustion, know the terms used to describe it, know what they mean, and know how to use them. The various words used to describe accidental chemical reactions--fire, explosion, detonation, deflagration--do have different meanings because they refer to different processes. Second, how a combustion happens is just as important as how much fuel there is. With these two ideas in mind, you should have a better understanding of combustion.

A biographical sketch of the author and a convenient Combustion Terminology Review are at the top of the next page.

Liquefied natural gas (LNG) vapors burning - a deflagration.



COMBUSTION TERMINOLOGY REVIEW

1. *Fire*--a non-technical term used to describe a combustion which does not cause a shock wave or overpressures.

2. *Deflagration*--a technical term used to describe a combustion which may or may not have shock waves or overpressures associated with it. If there is a shock wave, the wave's speed cannot exceed the speed of sound as measured at the conditions of the flame front.

3. *Detonation*--a technical term used to describe a combustion which causes a shock wave that moves at the speed of sound as measured at the conditions of the flame front.

4. *Explosion*--a non-technical term used to describe a combustion which causes a shock wave that moves at or below the speed of sound as measured at the conditions of the flame front.

5. *Confined*--surrounded by a set of walls (re: a burning gas-air mixture).

6. *Unconfined*--(a burning gas-air mixture) without a surrounding set of walls.

About the Author

Dr. Alan L. Schneider earned his Doctorate in chemical engineering in 1973 from the Massachusetts Institute of Technology. He has been working as a chemical engineer since 1974 with the Cargo and Hazardous Materials Division, Technical Support Section of the Hazard Evaluation Branch at Coast Guard Headquarters. In this field, Dr. Schneider is concerned with liquefied natural gas, fire and explosion phenomena, and computer simulation of cargo releases.

Dr. Schneider frequently contributes to the *Proceedings*. His two most recent articles were "LNG Research Overview," which appeared in the March-April 1979 issue, and "U.S. Coast Guard Risk Analysis" (co-authored with Mr. Robert C. Lambert), published in the December 1978 issue.

ESCAPE!

Plan and Practice for a Safe Escape

Home fire drills may sound silly, and a serious fire is no fun to talk about, but a little time spent selecting escape routes and practicing what to do may save lives if fire ever comes to your home.

1. Walk through the main escape route several times. Try it in the dark or with eyes closed. Memorize the number of steps between obstacles or turns. If a piece of furniture keeps getting in the way, move it to clear the path.

2. Plan alternate ways of escape from each room. If the main route were blocked by fire or impenetrable smoke, how would each family member get out? If bedroom windows are too high for safe jumping, perhaps you should buy rope or chain escape ladders to keep at a window in each bedroom.

3. If you must go through a smoke-filled area, crawl on hands and knees, with your head low to avoid breathing smoke.

4. Before opening an inside door, touch the knob and the top of the door. If either feels hot, don't open the door. Fire on the other side might flash into your room. Use your secondary escape route.

5. Agree on a place to meet outside the home, so you can count noses and be sure everyone is safe.

6. Don't call the Fire Department from the burning home. Get out safely, then telephone from a neighbor's home or use an alarm box.

7. Go back into the house or apartment *only* after the firefighters have assured you that the fire is fully extinguished and the structure is sound.

FIRE PREVENTION WEEK 1979

Fire causes more loss of life and property in the United States than all other natural disasters combined. Fire is the second most frequent cause of accidental death in the home. Volunteer and professional firefighters bear a disproportionate burden of the human costs of fire; firefighting is still America's most hazardous profession.

Last year, 8,700 Americans died, 280,000 were injured in fires and $5 billion in property was lost. America's loss to fire is among the very highest in the industrialized world.

As evidence of my strong personal concern about our fire problem, I have implemented a Reorganization Plan that puts the Federal government's principal fire programs in the new Federal Emergency Management Ageney. This agency now coordinates America's disaster preparedness and response efforts. But the Federal government alone cannot reduce America's fire losses. The public and private sector must do their part. Together we can lessen this unnecessary, life-threatening destruction.

NOW, THEREFORE, I, JIMMY CARTER, President of the United States of America, do hereby designate October 8-14, 1979 as Fire Prevention Week.

Because fire deaths most often occur in homes, I call upon American families and other property owners to install smoke detectors, to practice exit drills, and to be especially vigilant in guarding against fires.

I encourage the fire service, police, prosecutors, the insurance industry, and government to work together to improve arson detection and prosecution so that we can begin to eliminate this costly, often murderous crime.

I call upon every fire department in the country to teach citizens the fundamentals of basic life support, cardio-pulmonary resuscitation, and to improve the delivery of emergency medical services.

I urge the fire service to fully open their profession to women, and I offer my support to the growing number of professional and volunteer women firefighters.

I encourage the fire service to take full advantage of the National Fire Academy that became a reality this year. The Academy will be an effective tool in providing training and education for the Nation's firefighters.

I support and encourage the cooperative efforts of private enterprise and government in developing low cost residential sprinkler systems that may revolutionize fire safety in the home.

Finally, I call upon members of the Joint Council of National Fire Service Organizations, members of the International Association of Fire Chiefs, the National Fire Protection Association, all other organizations concerned with fire safety, and the United States Fire Administration to provide the leadership, planning and innovation necessary for an effective national fire prevention and control effort.

IN WITNESS WHEREOF, I have hereunto set my hand this fifteenth day of August, in the year of our Lord nineteen hundred seventy-nine, and of the Independence of the United States of America the two hundred and fourth.

(signed)
JIMMY CARTER

Captain Small Renews His License

On July 10, 1979 the Officer in Charge at the Coast Guard Marine Inspection Office, St. Ignace, Michigan renewed the license of Captain Thomas A. Small to serve as "Master of Steam and Motor Vessels of any Gross Tons upon the waters of the Great Lakes; also, First Class Pilot of Steam and Motor Vessels of any Gross Tons upon the Great Lakes their connecting and tributary waters between Gary, Duluth and Buffalo." Captain Small is 106 years old.

Captain Small is the oldest person to have been licensed to date. He is the holder of the license with the highest issue number, having been licensed for more than 80 years. The issue number on his new license is 14-17, which means it is his 14th master's license and his 17th license as Pilot, Mate or Master.

The earliest record maintained at U.S. Coast Guard Headquarters for Captain Small concerned a license issued by the Steamboat Inspection Service of the Department of Commerce and Labor, a predecessor agency to the Coast Guard. That license was issued at Marquette, Michigan on March 22, 1910 with issue number 1,4 authorizing service as "Master and First Class Pilot of Steam Vessels upon lakes Superior, Michigan, Huron and Erie and connecting and tributary waters between Duluth, Chicago and Buffalo, unlimited tonnage." Evidence indicates the previous three licenses were for First Class Pilot with initial examination on March 6, 1899. Captain Small's original master's license, which was still in the files, was presented to him along with his new license by Commander Timothy G. McKinna.

Captain Small was born in Collingwood, Ontario, Canada, on October 18, 1873. He became a naturalized U.S. citizen on February 17, 1899.

His career on the Great Lakes began in 1896, when he operated a donkey engine for a predecessor company of the present U.S. Steel fleet. Later that season, he sailed aboard the STR HOYT for his first voyage.

Captain Small has served on many vessels, and has more "sea stories" to tell than could ever be counted. He retired from U.S. Steel in 1938, and holds the record for the all time longevity mark among U.S. Steel pensioners. The centarian-plus claims that remaining active and busy is one of the reasons for his long life. He prefers the "cooler" climate of upper Michigan to that of any other area in which he has lived. He is healthy, alert, interested in day to day events, and shakes hands with the strength of a man half his age. To the oldest living skipper we extend warm wishes for continued good health and happiness.

Lessons from Casualties

The hull of a Japanese motor vehicle carrier was holed by its anchor while the vessel was proceeding to anchorage. The vessel was underway in the Columbia at the time.

The vessel was under control of a Columbia River Pilot who boarded the vessel at Astoria, Oregon for the trip up river to Portland, Oregon. The transit up river was without incident. The vessel was approaching the anchorage at approximately 13-15 knots. At this time, the master set the anchor detail consisting of three crewmen. They were the chief mate, carpenter, and bosun. Ten minutes after setting the special sea detail, the vessel was slowed to approximately 2-5 knots and the starboard anchor was let go with 5 shots of chain in 60 feet of water.

The vessel's normal anchoring procedure was to have the bosun run the windlass under the supervision and direction of the chief mate. Although the chief mate stated that he normally lowers the anchor down to just below the waterline, he denied lowering it any more than that during this anchorage. The windlass appeared in good condition with no signs of excessive rust or deterioration. The starboard anchor weighs 11,817 pounds.

The master made a log entry after the fact that at the time of letting go the starboard anchor he "felt slightly shock starboard." The incident was not reported to the pilot and no other crewmember felt the shock or noticed anything unusual.

Later, as the pilot was departing the vessel, he noticed that there was oil in the water around the vessel. A visual examination of the hull from a motor launch revealed two holes and one crack in the area of the number one fuel tank. The holes were about 1 inch by three-fourths of an inch about 60 to 67 feet aft of the bow, and 4'5" to 5'8" up from the heel. Inspection of the damaged area revealed that the holes and crack were apparently caused by the tips of the flukes of the starboard anchor. There were arched scratches and gouges on the plating where the anchor had on many occasions swung aft, against the hull of the ship. There were 10 other significant dents in the area of the holing that were apparently caused by the anchor flukes. Similar markings were found on the port side of the vessel.

The total amount of bunker oil leaked from the vessel was approximately 26,400 gallons which resulted in a $1,000,000 cleanup operation. A 12-foot square insert was placed in the damaged area of the vessel which cost $114,682.00.

This casualty demonstrates the problems encountered when a conning officer allows his vessel to advance through the water with its anchor hanging below the waterline at a speed which would allow the anchor to swing along the side of the vessel. The casualty may have been averted had the chief mate lowered the anchor from the hawse pipe to just above the water line and let go the anchor with little or no way on the vessel.

Marine Safety Council Membership

Wayne Eugene Caldwell, a native of Springfield, Ohio, graduated at the head of his class from Springfield High School in 1941. After taking a freshman year of engineering at Ohio State University, he went on to earn a B.S. degree from the Army Civil Engineering Special Training School at Kansas State College, Manhattan, Kansas. He was credited with service in the U.S. Army Reserve from November 1942 to May 1943, and with the Army Combat Engineers until July 1944.

Appointed to the U.S. Coast Guard Academy, New London, Connecticut during World War II, he was commissioned an Ensign and received a B.S. degree in marine engineering in 1948. Immediately after graduation he was assigned to the Academy for a brief period as physical education instructor and assistant football coach. From November 1948 to March 1951, he served as Deck Watch Officer on board the 311-foot USCG cutter BARATARIA out of Portland, Maine, on ocean station patrol duty in the Atlantic. After a brief stint as Operations Officer at the Coast Guard Base at Boston, he was assigned as a communications student at the U.S. Naval Postgraduate School, Monterey, California. In July 1952 he returned to the Academy to serve as mathematics instructor, company tactics officer, education officer, assistant football coach and assistant track coach.

He served his next tour of duty in Alaskan waters, first as Executive Officer and eventually as Commanding Officer of the buoy tender USCGC HEMLOCK. When that vessel was decommmissioned in July 1958, he was appointed Executive Officer of the USCGC BALSAM for a year. Both vessels operated out of Ketchikan, Alaska.

From July 1959 to July 1963, he was stationed as Chief, Communications Section in the 11th Coast Guard District office at Long Beach, California. Next, he served as Executive officer on board the cargo vessel USCGC KUKUI out of Honolulu on logistics missions to Loran stations and other outposts in the pacific. In June 1965, he again returned to the Academy to serve as Assistant Commandant of the Cadets for four years. For his outstanding performance in that post he was awarded the Coast Guard Achievement Medal.

From June 1969 to July 1971, he commanded the 378-foot USCGC CHASE based at Boston. During that period the cutter was deployed to Southeast Asia from September 1969 to July 1970. For meritorious service in the Vietnam conflict he was awarded the Bronze Star Medal. He was cited for seven anti-infiltration patrols and 35 naval gunfire support missions to aid allied ground forces. Under his command, the cutter carried out a variety of humanitarian missions that included the treatment of 1,032 Vietnamese civilians by MEDCAP (Medical Civic Action Projects) teams from the CHASE sent into various villages, and the construction of a playground for children by crew members.

Rear Admiral Caldwell next was assigned as a student at the National War College, Fort Lesley J. McNair, Washington, DC and simultaneously entered the graduate school at George Washington University. Upon graduating a year later with a Master of Science degree in International Affairs from George Washington University as well as a National War College certificate, he reported to Coast Guard Headquarters as Chief, Officer Personnel Division. For his contributions during that assignment he was awarded the Meritorious Service Medal. In June 1974, he was reassigned at Headquarters to the post of Deputy Chief, Office of Marine Environment and Systems.

In July 1975, he returned to New London for one year as Assistant Superintendent of the Coast Guard Academy. While in that post, by Presidential nomination and following Senate approval, then-Captain Caldwell was appointed a flag officer to rank as Rear Admiral from July 1, 1976. At that time he assumed the post of Commander, 2nd Coast Guard District, St. Louis, Missouri. Upon detachment he was awarded a gold star in lieu of a second Meritorious Achievement Medal.

The Admiral returned to Headquarters in June 1979 to serve as Chief, Office of Marine Environment and Systems, where he is presently stationed.

Rear Admiral Caldwell's campaign and service medals include: American Area, American Defense Service (with star), World War II Victory; Army Good Conduct; Bronze Star Medal (Sept. 1970) for Vietnam combat duty, Vietnam Service Medal, Republic of Vietnam Medal, Vietnam Civil Action and Vietnam Gallantry Cross Unit Citation; Navy Unit Citation, Expert Rifle; Coast Guard Achievement Medal (May 1969) and Meritorious Service Medal (April 1974 and June 1979).

Mrs. Caldwell is the former Suzanne Jamison of Dallas and San Antonio, Texas. She and Rear Admiral Caldwell have three children, two daughters and one son.

Nautical Queries

The following items are examples of questions included in the Third Mate and Second Assistant Engineer examinations.

DECK

(1) The fog most commonly encountered at sea is called

A. conduction fog.
B. radiation fog.
C. frontal fog.
D. advection fog.

REFERENCE: Bowditch

(2) A marine sextant has the index arm set at zero and the reflected image of the horizon forms a continuous line with the actual image. When the sextant is rotated about the line of sight, the images separate. The sextant has

A. error or perpendicularity.
B. side error.
C. prismatic error.
D. centering error.

REFERENCE: Bowditch

(3) Which of the following factors has the greatest effect on the amount of gain required to obtain a fathometer reading?

A. The salinity of water.
B. The temperature of water.
C. The atmospheric pressure.
D. The type of bottom.

REFERENCE: Bowditch

(4) The error introduced in a gyrocompass by the rolling of the vessel is called

A. quandrantal error.
B. Gimballing error.
C. Ballistic deflection error.
D. damping error.

REFERENCE: Bowditch

(5) A local wind which occurs during the daytime and is caused by the different rates of warming of land and water is called a

A. foehn.
B. chinook.
C. land breeze.
D. sea breeze.

REFERENCE: Bowditch

ENGINEER

(1) The purpose of a photo electric cell installed on an auxiliary boiler is to secure the

A. oil in the event of flame failure.
B. fire in the event of low water.
C. air in the event of high water.
D. oil in the event of high fuel oil temperature.

REFERENCE: Modern Marine Engineers Manual, Osbourne

(2) Cloudy or milky appearing oil in a lube oil system could be caused by

A. insufficient cooling water to the lube oil cooler.
B. excessive cooling water to the lube oil cooler.
C. insufficient gland sealing steam.
D. excessive gland sealing steam.

REFERENCE: Lubrication, Raymond C. Gunther

(3) Constant treatment of boiler feedwater with chemicals will

A. increase the level of total dissolved solids and sludge.
B. decrease frequency of blowdown.
C. decrease the possibility of carryover.
D. control the amount of suspended and precipitated solids.

REFERENCE: Practical Boiler Water Treatment, Pincus

(4) Dehydrators are usually located in the liquid line of R-12 refrigeration plants in order to

A. remove oil from the refrigerant.
B. prevent icing of the expansion line.
C. reduce compressor discharge line sweating.
D. prevent liquid slugging in the suction line.

REFERENCE: Commercial and Industrial Refrigeration, Nelson

(5) If a plunger or barrel is found to he worn or damaged in a jerk pump system

A. replace either damaged part.
B. replace plunger and barrel as a unit.
C. use increased rack setting to compensate for wear.
D. decrease the length of the high pressure fuel line to compensate for wear.

REFERENCE: Diesel Engine Operation and Maintenance, Maleev

ANSWERS

Deck
1. D; 2. B; 3. D; 4. A; 5. D

Engineer
1. A; 2. D; 3. A; 4. B; 5. B

MERCHANT MARINE SAFETY PUBLICATIONS

The following publications may be obtained from the nearest marine safety office, marine inspection office or by writing: **Commandant (G-CMA/TP26), U.S. Coast Guard, Washington, DC 20593.** Because changes to the rules and regulations are made from time to time, these publications can be kept current between revisions only by referring to the Federal Register. (Official changes to all Coast Guard authored federal regulations are published as final rules in the Federal Register on Mondays or Thursdays.) Following the title of each publication in the table below are the dates of the most recent editions and changes, if any.

The Federal Register may be obtained by subscription ($5 per month or $50 per year) or by individual copy (75 cents each) from SupDocs, U.S. Government Printing Office, Washington, DC 20402.

CG No.	TITLE OF PUBLICATION
CG-101-1	Specimen Examinations for Merchant Marine Deck Officers (2nd and 3rd Mate) (4-77).
CG-101-2	Specimen Examinations for Merchant Marine Deck Officers (Master and Chief Mate) (7-78).
CG-108	Rules and Regulations for Military Explosives and Hazardous Munitions (4-72).
CG-115	Marine Engineering Regulations (8-77).
CG-123	Rules and Regulations for Tank Vessels (8-77). Ch-1, 4-78.
CG-169	Navigation Rules - International - Inland (5-77).
CG-169-1	Colregs Demarcation Lines (7-77).
CG-172	Rules of the Road - Great Lakes (7-72).
CG-174	Manual for the Safe Handling of Flammable and Combustible Liquids and Other Hazardous Products (9-76).
CG-176	Load Line Regulations (2-71).
CG-177	Yacht Admeasurement and Documentation (9-72).
CG-182-1	Specimen Examinations for Merchant Marine Engineers License (2nd and 3rd Assistant) (4-75).
CG-182-2	Specimen Examinations for Merchant Marine Engineer Licenses; First Assistant Engineer, Steam and Motor, any Horsepower (4-76).
CG-182-3	Specimen Examinations for Merchant Marine Engineer Licenses; Chief Engineer Steam and Motor, any Horsepower (4-76).
CG-190	Equipment Lists (8-77).
CG-191	Rules and Regulations for Licensing and Certificating of Merchant Marine Personnel (11-76) Subchapter B.
CG-227	Laws Governing Marine Inspection (7-75).
CG-239	Security of Vessels and Waterfront Facilities (5-74).
CG-242	International Conventions & Conferences on Marine Safety (6-51).
CG-257	Rules and Regulations for Cargo and Miscellaneous Vessels (9-77). Ch-1, 3-78.
CG-258	Rules and Regulations for Uninspected Vessels (4-77). Ch-1, 3-78.
CG-259	Electrical Engineering Regulations (7-79).
CG-268	Rules and Regulations for Manning of Vessels (7-77).
CG-293	Miscellaneous Electrical Equipment List (6-73).
CG-323	Rules and Regulations for Small Passenger Vessels (7-77). Ch-1 3-78.
CG-329	Fire Fighting Manual for Tank Vessels (1-74).
CG-388	Chemical Data Guide for Bulk Shipment by Water (1976).
CG-403	Great Lakes Pilotage Regulations (7-76).
CG-439	Bridge to Bridge Radiotelephone Communications (12-72).
CG-467	Specimen Examinations for Uninspected Towing Vessel Operators (10-74).
CG-474	When You Enter That Cargo Tank (3-76).
CG-478	Liquefied Natural Gas, Views and Practices, Policy and Safety (2-76).
CG-480	Oil Pollution Control for Tankermen (6-75).
CG-482	Benzene Safe Handling Practices (12-76).
CG-486	Shippers Guide to Hazardous Materials Regulations (Water Mode) (8-77).
CG-491	Safety for Small Passenger Vessels (8-77).
CG-497	Rules and Regulations for Recreational Boating (7-77).
CG-515	Rules and Regulations for Foreign Vessels Operating in the Navigable Waters of the U.S. (2-78).
CG-518	Marine Investigating Officer's Regulation Handbook (2-78).
CG-526	Utilizing the Packaged Hazardous Materials Regulations, 49 CFR (5-78).
Safety of Life at Sea: Convention, with Regulations, London, June 17, 1960.	
Specifications for Merchant Vessel Equipment (Subparts of Chapter Q, 46 CFR, parts 160 to 164.	

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