technical note technical note

Fire Testing of Ethanol-Based Hand Cleaner

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16. Abstract

A variety of laboratory and full-scale fire tests were conducted on an ethanol-based gel-type hand cleaner currently used in commercial aircraft lavatories. The waterless-type hand cleaner has a relatively low flash point, raising concern over its fire safety when in use in the galley area of commercial transport aircraft where radiant ovens are often located. The results indicated the gel hand cleaner is often difficult to ignite and can be extinguished relatively easily.

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EXECUTIVE SUMMARY

The Honolulu Flight Standards District Office (FSDO) was approached by a Part 121 operator inquiring about the requirement to install and utilize an ethanol-based waterless hand cleaner system in the galley area of their aircraft. The product, identified as Sanitizer Gel Dispensing System, was designed by Celeste Industries Corporation and is currently approved for use in aircraft lavatories. The operator was advised by the FSDO that they have the responsibility to review and approve/disapprove the installation of such a dispensing system. However, after reviewing the ingredients of the product, FSDO concluded that the Civil Aviation Security Field Office (CASFO), Dangerous Goods Specialist should be involved because of their expertise with dangerous goods. The CASFO, in coordination with their Regional personnel, recommended against the use of the product on airplanes because of the low flash point (72^{o}F) and cited the potential for other fire hazards due to spillage, broken containers, misplaced dispensing units, etc.

The FSDO contacted the Fire Safety Section at the Federal Aviation Administration (FAA) William J. Hughes Technical Center at the Atlantic City International Airport, NJ, for their assistance in evaluating the product. The Fire Safety Section agreed to take a closer look at the possible dangers of this product from a fire safety standpoint. Celeste Industries Corporation provided samples of the product to the Technical Center for evaluation and testing. Several test scenarios were set up and trials were run to investigate the potential hazards. The results indicate the gel hand cleaner is often difficult to ignite and can be extinguished relatively easily.

INTRODUCTION

PURPOSE.

The purpose of this technical note is to describe the fire tests conducted on an ethanol-based waterless hand cleaner manufactured by Celeste Industries Corporation. Conditions representing in-service fire safety concerns were arranged and investigated.

BACKGROUND.

An ethanol-based gel hand cleaner manufactured by Celeste Industries Corporation has been approved for use in the lavatory area of commercial transports. The product, identified as Sanitizer Gel Dispensing System, has a flash point of 72°F. The flash point is the minimum temperature of the gel that allows for ignition by a small flame. The Honolulu Flight Standards District Office (FSDO) was approached by a Part 121 operator that inquired about the requirements to install and utilize this product in the galley area of its aircraft. This raised concern amongst the FSDO personnel who are responsible for overseeing the safe operation of commercial aircraft. At issue was the fact that radiant ovens are used extensively in the galley area of commercial transport aircraft, adding to the possibility that the hand cleaner gel could be heated to a temperature above its flash point, and a small ignition source could ignite the substance. After reviewing the ingredients of the product, FSDO felt that the Civil Aviation Security Field Office (CASFO), Dangerous Goods Specialist needed to be involved because of their expertise with dangerous goods. The CASFO, in coordination with their Regional personnel, recommended against the use of the product on airplanes because of the low flash point and cited the potential for other fire hazards due to product spillage from broken containers.

The Fire Safety Section at the FAA William J. Hughes Technical Center was contacted and agreed to assist in evaluating the product. Celeste Industries provided samples of the product to the Technical Center for evaluation and testing. Several test scenarios were set up and trials were run to investigate the potential hazards.

DISCUSSION

INITIAL TESTS.

Several simple tests were performed to determine the flammability of the hand cleaner gel. These tests were designed to simulate conditions that could exist in the galley area of an aircraft. During the first test, a 6-inch-diameter puddle of gel weighing 44.6 grams was poured onto a metal surface and exposed to a lit book match. After approximately 1 to 2 seconds, the gel ignited. The light-blue flame temperature, approximately 1100°F as measured with a type K open-bead thermocouple, was relatively low. The maximum height of the flame reached approximately 9 inches, and the material flamed for 6 minutes 25 seconds. The gel did not flash violently when exposed to the ignition source, but required a short time to sustain combustion. After the test, white soap residue was found on the metal surface. A second test was conducted in which 52.4 grams of gel was ignited in a similar manner. The results were nearly identical to

the first test in terms of temperature, flame height, flame color, and flame time (6 minutes 20 seconds).

During the third test, the flammability of dry "crumpled" paper towels was compared to like towels soaked with the hand cleaner gel. This simulated a situation in which towels were used to wipe the hand cleaner from a person's hands prior to disposal. Ten dry paper towels were crumpled into a small pile next to an identical pile in which the towels were previously soaked with 71.9 grams of cleaner. Two book matches were ignited and simultaneously placed on the dry and soaked paper towels. It took a few seconds for each match to ignite the respective piles of towels. Once ignited, the flame color of the gel-soaked towels appeared to be more orange than that of the dry ones. The burning time of the dry towels was approximately 2 minutes 25 seconds, while the soaked towels burned for 8 minutes 30 seconds before self-extinguishing. Thus, the dry towels were more flammable than the gel-soaked towels. Again, no violent flash occurred when the soaked towels were exposed to the ignition source.

The next test condition simulated an inadvertent spray of gel across an ignition source. First a crumpled paper towel was ignited. Next, the gel cleaner was expelled from its bottle container by striking the pump dispenser with a weighted object (the dispensing arm was struck from a short distance remote to the flaming paper for safety reasons). About 5 to 6 seconds after the paper was ignited, the squirts of gel were discharged directly into the fire (figure 1). Each squirt was subsequently measured at about 0.60 to 0.65 grams. The resultant squirting of gel onto the fire did not result in any flashing, but may have contributed to a longer flame duration and possibly changed the flame color from yellow to yellow-orange.

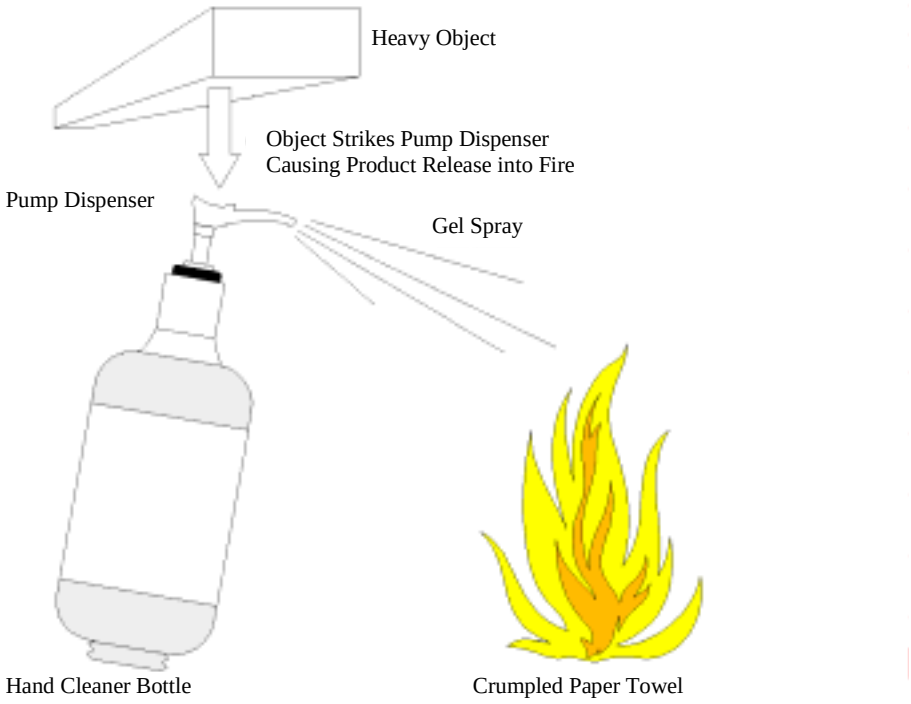

FIGURE 1. TEST ARRANGEMENT—SQUIRTING GEL INTO FIRE

During the next test scenario, the effect of a small fire underneath a plastic wall-mounted bottle of hand cleaner was determined. A pile of 50 crumpled paper towels was ignited. The plastic bottle of gel was mounted approximately 12 inches above the base of the fire on a mounting bracket that oriented the bottle at 12 degrees with respect to a vertical plane (figure 2). The sequence of events is listed in table 1. As shown, the fire enveloped the plastic bottle of gel which melted and subsequently released its contents into the burning pile of paper, but no flash or explosion resulted.

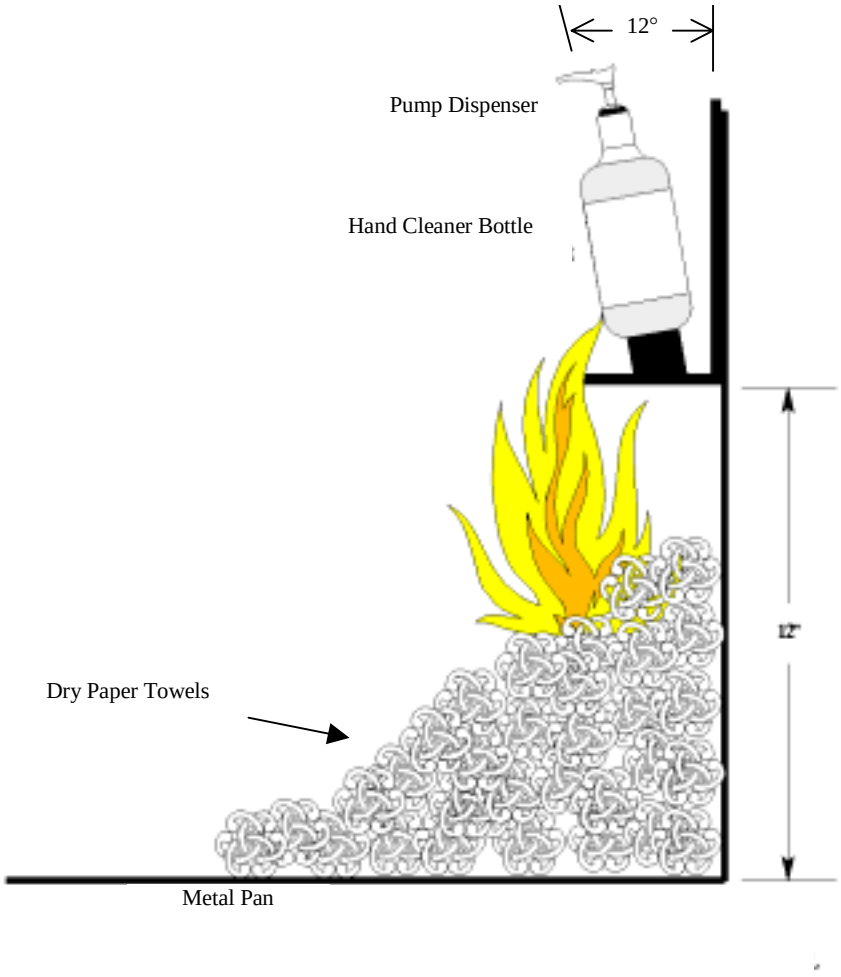

FIGURE 2. TEST ARRANGEMENT—SMALL FIRE UNDER WALL-MOUNTED BOTTLE OF GEL

TABLE 1. SEQUENCE OF EVENTS, SMALL FIRE UNDER WALL-MOUNTED BOTTLE OF GEL

Time (seconds)	Event
0	Start ignition
26	Flames reach base of the hand cleaner bottle
52	Flames reach the pump tip of the bottle
73	Pump tip lever begins to melt
75	Off-gassing of materials through lever tip
83	Paper flames fully developed
84	Dispenser pump tip lever significantly melted, drops into pan
95	Dispenser bottle partially melted, drops into pan
107	Flame could be seen on the side of the bottle that faced down
195	Cleaner gel started to drop onto the paper fire changing the color from yellow to slightly orange
428	Flame on the bottle self extinguishes
780	Paper fire self extinguishes, test terminated
780+	After test, bottle collapsed towards the pan
780+	A very small amount of hand cleaner gel was found in the bottle

ADDITIONAL TESTS.

After the initial round of tests were completed, some additional tests were conducted to obtain a more complete understanding of the material under the widest range of situational scenarios.

Several tests were conducted to determine how difficult it was to extinguish a small puddle of burning hand cleaner. An 8-inch-diameter puddle containing approximately 75.2 grams of gel was ignited and allowed to burn for 90 seconds. At this point, small quantities of tap water (approximately 1 fluid ounce each) were poured onto the fire intermittently, resulting in partial displacement of the flaming gel. The flaming gel was completely extinguished in approximately 10 seconds, which required 308 grams of water. This test was repeated using slightly more gel hand cleaner, 95.5 grams. Results were similar to the first trial, requiring 7 seconds for extinguishment and only 95 grams of water. A third test was conducted using a hand-held fire extinguisher with the same 8-inch-diameter puddle of gel, weighing 102.5 grams. The air-charged 2-gallon capacity hand-held extinguisher was outfitted with a low flow-rate nozzle with a measured output of 0.74 gallon per minute (gpm). After igniting the gel with a match, the flames were allowed to burn for 115 seconds before the extinguisher was activated. Upon activation, the fire appeared to be extinguished by the initial blast of air exiting the nozzle prior to any water discharge. A subsequent measurement of the extinguisher contents revealed that only 4.5 grams of water had been expelled. Another similar test was conducted using a Halon 1211 handheld extinguisher against the 8-inch-diameter puddle fire containing 101.7 grams of gel. After the fire was allowed to burn for 116 seconds, the extinguisher was discharged over the burning material resulting in immediate extinguishment. As with the

previous test using the water extinguisher, it appeared that the fire was extinguished as a result of the initial blast of air prior to any extinguishant application. A subsequent weighing revealed only 4.5 grams of suppressant released. At this point, an additional test was conducted in which compressed air was discharged over the burning material. This too resulted in immediate extinguishment of the fire and confirmed the observations of the previous tests using actual extinguishers.

During the next series of tests, a heated 7.875-inch-diameter steel cooking pan was placed on a puddle of the gel hand cleaner to determine the likelihood of ignition. The puddled hand cleaner measured 12 inches in diameter and weighed 140 grams, which represented a fairly large spill on the countertop surface in a galley. The steel cooking pan was first placed in an oven set at the maximum temperature of 400^{o}F for a period of 1 hour and 20 minutes. A thermocouple was attached to the bottom of the pan to measure the surface temperature, which was approximately 401 to 405^{o}F. The heated cooking pan was then placed on top of the puddle of hand cleaner, which resulted in smoke emanating from around the 5.5-inch-diameter base of the cooking pan. No flames were produced, and the test was terminated after 1 minute. This test scenario was repeated using 173.5 grams and again with 179.8 grams of hand cleaner in the same 12-inch diameter puddle. The cooking pan bottom surface temperature was recorded at 414^{o}F and 404^{o}F, respectively, before being placed in the puddle. Again, the application did not result in any flaming condition. Smoke was produced at the contact point.

During the next three tests, measured amounts of hand cleaner gel were placed on the hot plate surface of an automatic drip coffee machine to determine the potential for ignition. The unit used in testing was manufactured by Hamilton Beach/Proctor Silex and utilized a heating-element plate that measured 4.375 inches in diameter. The coffee machine was turned on and allowed to heat up for more than 30 minutes, at which point the plate surface was measured to be 261^{o}F. A 62.9-gram quantity of hand cleaner gel was placed directly onto the hot plate surface. The gel boiled in a matter of seconds and continued for approximately 14 minutes, at which point the boiling ceased. The test was terminated after an additional 3 minutes of heating. During the boiling process, the gel formed into a white soapy residue which remained after test completion. No flames resulted during the test. Two more trials were completed under nearly identical conditions which also resulted in boiling off of the gel and no incidence of flames.

During the next test arrangement, the upper surface of a cooking mitten commonly used for hand protection when handling hot oven cookware was coated with several ounces of hand cleaner gel and placed in a heated oven to test for flammability. The oven used was a laboratory grade device with internal dimensions of 28 inches wide by 18 inches deep by 22 inches high. A thermocouple was mounted through a 1-inch hole in the upper surface of the oven to accurately measure the internal temperature. The oven was preheated in excess of 2 hours prior to insertion of the gel-coated mitten. The temperature was 400^{o}F at the start of the test. Visual checks were made at 7 minutes and 17 minutes into the test, during which time the internal temperature was measured at 361^{o}F and 364^{o}F, respectively. No flames or traces of combustion were observed. Additional checks were made at 23, 28, 33, 39, and 46 minutes into the test, again with no traces of flames or combustion. The internal temperature of the oven ranged from 350 to 379^{o}F during these observations. After test termination, the mitten was observed to be dry to the touch and

completely void of all traces of the hand cleaner gel. A second test was performed and yielded identical results.

Two final tests were conducted using the standardized lavatory trash receptacle test article for evaluating halon replacement agents [1]. When conducting tests to evaluate the effectiveness of a halon replacement agent, 815 grams of paper hand towels are crumpled and loaded into a small test article with internal dimensions of 18 inches wide by 8 inches deep by 16 inches high. The towels are ignited by a glowing nichrome wire that represents a burning cigarette or other small ignition source. Because the current test method was based on a dry fire load, there was concern over the effectiveness of the present extinguishing agents at suppressing a more severe fire fueled by ethanol-laden towels. Two tests were conducted in which a fraction of the dry crumpled paper towels used as the fire load were first wiped with the gel hand cleaner prior to being loaded into the test article. In order to accomplish this, the tester placed two "pumps" of cleaner in his hands then immediately wiped with a dry towel. The tester then continued to crumple the towels in the normal fashion outlined in the trash receptacle extinguisher testing document.

During the first test in this series, approximately 50% of the 815 grams total fire load (405 g) consisted of towels with hand cleaner residue, while the remaining 410 grams consisted of the normal dry crumpled towels. After ignition of the test materials, the fire appeared to progress normally, despite the added content of flammable gel. The Halon 1301 bottle discharged at approximately 205 seconds into the test, and the temperature in the center of the test receptacle reached 727^{o}F; both the discharge time and temperature are very typical for this particular experiment (table 2). After discharge, the tester must wait 5 minutes before opening the observation window of the test receptacle. After an additional 2 minutes, the contents of the receptacle must be emptied onto a pan for inspection. During the first test, the fire was successfully extinguished.

TABLE 2. SEQUENCE OF EVENTS, LAVATORY TRASH RECEPTACLE TEST, 50% OF LOAD CONTAINING GEL COATED HAND TOWELS

Time (seconds)	Event
0	Nichrome wire igniter energized
13	Smoke emanated through the infiltration hole
21	Smoke emanated from the lid of the test receptacle
55	Flames could be seen in the test receptacle through the infiltration hole
205	Halon 1301 agent was automatically discharged from the fire extinguisher into the paper fire. At this time, the temperature of the surface of the fire extinguisher was 21.7^{o}F. The temperature at the center of the test article was 727^{o}F.
205+	Five minutes after the agent discharged the glass observation window was opened. No flaming conditions occurred in the test receptacle. Two minutes subsequent to the window opening, the crumpled towels were emptied from the test receptacle and placed onto the observation pan. No smoke or flames were observed on the paper towels.
	Successful extinguishment

A second test was conducted in which 75% of the 815 grams (610 g) of towels contained residue of the gel hand cleaner, and the remaining 205 grams were dry crumpled towels. Again, this fire was successfully extinguished (table 3). The only perceived difference between the normal test and the tests using hand cleaner-wiped towels was an elevated level of smoke from the test article.

TABLE 3. SEQUENCE OF EVENTS, LAVATORY TRASH RECEPTACLE TEST, 75% OF LOAD CONTAINING GEL COATED HAND TOWELS

Time (seconds)	Event
0	Nichrome wire igniter energized
11	Smoke emanated of the lid of the test receptacle
13	Smoke emanated through the infiltration hole
54	Flames could be seen in the test receptacle through the infiltration hole
174	Halon 1301 agent was automatically discharged from the fire extinguisher into the paper fire. At this time, the temperature of the surface of the fire extinguisher was 22.8^{o}F. The temperature at the center of the test article was 740^{o}F.
174+	Five minutes after the agent discharged the glass observation window was opened. No flaming conditions occurred in the test receptacle. Two minutes subsequent to the window opening, the crumpled towels were emptied from the test receptacle and placed onto the observation pan. No smoke or flames were observed on the paper towels.
	Successful extinguishment (119.7 grams of Halon 1301 used)

CONCLUSION

A review of the tests performed indicates that the hand cleaner gel does not spontaneously ignite when exposed to elevated temperatures as exhibited by the heated cooking pan, the hot plate (coffee machine), and the cooking mitten inserted into the preheated oven. Furthermore, when the hand cleaner gel is ignited with an open flame source and combustion is allowed to progress, the flames are very easily extinguished, as observed using a small blast of compressed air. When the gel is forcibly pumped or squirted into an open flame, no flashing results. During a fire of more significant intensity, a full bottle of the hand cleaner placed directly into the flames did not result in any fire hazard. Most importantly, the testing also confirmed that when the fire load used in the current test method for evaluating lavatory trash receptacle halon replacement agents contained paper towels with hand cleaner gel residue, the fire can still be extinguished.

REFERENCE

1. Marker, T., Development of a Minimum Performance Standard for Lavatory Trash Receptacle Automatic Fire Extinguishers, DOT/FAA/AR-96/122, February 1997.

Appendix – List of FAA Technical Reports Published in FY98

Report Number	Title
R&D Highlights 1998	Highlights of the major accomplishments and applications.
DOT/FAA/AR-TN97/50	Comparison of Radial and Bias-Ply Tire Heating on a B-727 Aircraft
DOT/FAA/AR-97/99	Fire-Resistant Materials: Research Overview
DOT/FAA/AR-95/18	User's Manual for the FAA Research and Development Electromagnetic Database (FRED)
DOT/FAA/AR-97/7	Advanced Pavement Design: Finite Element Modeling for Rigid Pavement Joints, Report II: Model Development
DOT/FAA/AR-97/26	Impact of New Large Aircraft on Airport Design
DOT/FAA/AR-97/64	Operational Evaluation of a Health and Usage Monitoring Systems (HUMS)
DOT/FAA/AR-TN98/15	Fire Testing of Ethanol-Based Hand Cleaner
DOT/FAA/AR-95/111	Stress-Intensity Factors for Elliptical Cracks Emanating from Countersunk Rivet Holes
DOT/FAA/AR-97/9	An Acoustic Emission Test for Aircraft Halon 1301 Fire Extinguisher Bottles
DOT/FAA/AR-97/37	Development of an Improved Magneto-Optic/Eddy-Current Imager
DOT/FAA/AR-97/69	Automated Inspection of Aircraft
DOT/FAA/AR-97/5	Marginal Aggregates in Flexible Pavements: Field Evaluation
DOT/FAA/AR-97/87	A Predictive Methodology for Delamination Growth in Laminated Composites, Part I: Theoretical Development and Preliminary Experimental Results
DOT/FAA/AR-TN97/103	Initial Development of an Exploding Aerosol Can Simulator
DOT/FAA/AR-97/56	Applications of Fracture Mechanics to the Durability of Bonded Composite Joints

Report Number	Title
DOT/FAA/AR-96/97	Stress-Intensity Factors Along Three-Dimensional Elliptical Crack Fronts
DOT/FAA/AR96/119	Vertical Drop Test of a Beechcraft 1900C Airliner
DOT/FAA/AR-98/22	FAA T53-L-13L Turbine Fragment Containment Test
DOT/FAA/AR-97/85	Response and Failure of Composite Plates with a Bolt-Filled Hole
DOT/FAA/AR-98/26	A Review of the Flammability Hazard of Jet A Fuel Vapor in Civil Transport Aircraft Fuel Tanks
DOT/FAA/AR-TN97/108	Effects of Concentrated Hydrochloric Acid Spills on Aircraft Aluminum Skin
DOT/FAA/AR-TN98/32	Cargo Compartment Fire Protection in Large Commercial Transport Aircraft
DOT/FAA/AR-98/28	Statistical Loads Data for Boeing 737-400 Aircraft in Commercial Operations
DOT/FAA/AR-97/47	Development of Advanced Computational Models for Airport Pavement Design
DOT/FAA/AR-98/34	Health Hazards of Combustion Products From Aircraft Composite Materials
DOT/FAA/AR-97/81	Bioremediation of Aircraft Deicing Fluids (Glycol) at Airports
DOT/FAA/AR-TN97/8	Heats of Combustion of High-Temperature Polymers
DOT/FAA/AR-95/29 ***FACT SHEETS***	Fiber Composite Analysis and Design: Composite Materials and Laminates, Volume I Note: This document's PDF is unique from the above documents in that some of the Adobe navigational tools cannot be used such as searching and bookmarking. To navigate in this document, page down to the Table of Contents, List of Figures, and List of Tables where the entries are linked to the body of the document.