June 18, 2004

Dr. Margaret Simonson, Chairperson
Science Advisory Committee
National Association of State Fire Marshals
1319 F Street, N.W., Suite 301
Washington, DC 20004

Re: OPEI Response to Request for Safety Data

Dear Dr. Simonson:

Through these comments, the Outdoor Power Equipment Institute (OPEI) timely responds to your June 1st request for comments. In that memo, you specifically requested for “the producers of finished [lawn and garden] products, engines, catalytic converters and pressurized tanks” to respond with technical “engineering data” and any “testing protocols” evaluating the safety implications of installing catalysts or pressurized fuel systems on wheeled lawn and garden equipment (like walk-behind mowers and riding mowers). Based in part on responsive technical comments from affected stakeholders, the NASFM will try “to determine if enough is known to say that catalytic converters and pressurized fuel tanks can be used safely” on wheeled lawn and garden products.

I. OPEI

OPEI is the national association whose members manufacturer both wheeled and handheld lawn and garden equipment, as well as the separate manufacturers of engines that power these wheeled products. Through these comments, OPEI is responding to you with all of the relevant information that it has been able to collect on short notice from its members and from public sources. OPEI is committed to working with its members and with fire and safety experts like NASFM to try and prevent potentially unsafe products from entering the marketplace. To help you understand some of the heat-related safety challenges that OPEI members must address, OPEI has prepared the enclosed Safety Background Document on Catalysts and Heat-Related Concerns, attached as Exhibit A.

The wheeled lawn and garden equipment industry is non-integrated and mostly comprised of hundreds of small manufacturers, who typically produce specialized products. The vast majority of OPEI’s members have never produced and have no experience or test results evaluating either catalysts or pressurized fuel systems as applied to wheeled products. NASFM may be able to obtain more specific engineering and test data as members gain the needed
knowledge and experience. Please let me know if you are interested in speaking directly with individual manufacturers within the OPEI membership.

II. OPEI’S TECHNICAL/ENGINEERING RESPONSE

As you know, the application of catalysts and pressurized fuel systems to wheeled products has arisen relatively recently in the context of proposed regulations developed by the California Air Resources Board (CARB). For the last several years, OPEI has worked proactively with CARB regulatory staff in response to CARB’s proposed new Tier III exhaust and evaporative emission regulations. (U.S. EPA apparently plans to evaluate this year the safety issues and concerns raised by the final CARB regulations. OPEI urges NASFM to be an active stakeholder in this process.)

During a 10-hour technical public workshop that CARB held in Sacramento on July 2, 2003, engineers from numerous OPEI members made extensive technical presentations which graphically illustrate the potential safety concerns with applying catalysts and pressurized fuel systems to wheeled products. Most of the CARB and industry engineering presentations are listed on the CARB website at www.arb.ca.gov/msprog/offroad/sore/workshop/workshop.htm. Enclosed is a video and a DVD copy of the highlights from these engineers’ July 2nd presentations. These DVDs, tapes and the enclosed Power Point presentations are the most useful engineering information that OPEI has in its possession which directly responds to the issues raised in NASFM’s June 1st memo. This CARB workshop is the only public forum in any venue at which NASFM’s safety concerns have been comprehensively discussed by safety experts and engineers.

In light of NASFM’s focus, this highlight video begins with the concluding remarks of Jim Medich representing the California Fire Chiefs Association. At the conclusion of Mr. Medich’s presentation, there is a provocative dialogue between Division Chief Medich, the CARB regulatory staff and the public audience on the need for the regulators to work closely with the fire chiefs to ensure there is a balance between competing environmental and safety goals.

After Mr. Medich’s presentation, the rest of the enclosed highlight tape follows in the sequence of the July 2nd OPEI technical presentations. First, Bill Latus, a Senior Engineer with Briggs & Stratton, documents the fact that the heat generated from a catalyst dramatically increases in response to catalyst efficiency and the oxidation of carbon monoxide. (See Mr. Latus’ Power Point Presentation, attached as Exhibit B.) Mr. Latus then critiques the CARB/SwRI test program of catalytic exhaust systems or prototype engines. The SwRI study did not address whether catalysts posed unacceptable safety risks when applied to operating equipment, much less equipment actually operating under real-world conditions. Instead, SwRI attached very large catalysts to prototype, modified engines operating under ideal and artificial laboratory conditions. Mr. Latus documents (through impressive thermal imaging) that SwRI never tested the hottest areas around the catalyst which generate the most significant heat. (Unfortunately, SwRI only measured the cooler air at a different part of the exhaust stream. SwRI never corrected their understated measurement location.) Bill Latus also documents that
even SwRI’s understated heat measurements frequently showed exhaust gas temperature rises in the range of 350°F (roughly a 35% increase) and exhaust gas temperatures frequently in excess of 1300°F under full load. The substantial increases in exhaust gas temperature resulted in substantial measured increases in the muffler skin temperatures.

Mr. Latus and the OPEI Engineering Consultant, Dr. Sahu, illustrate and explain the well-established temperatures at which: (1) plastic fuel tanks and other plastic components on lawn and garden equipment will melt; (2) gasoline fumes will ignite, and (3) grass clippings will ignite. (See Exhibit A.) Enclosed as Exhibit C is a copy of portions of Dr. Sahu’s PowerPoint presentation. Dr. Sahu also explains that the exhaust gas temperatures, as well as the muffler surfaces temperatures from catalytic exhaust systems (as measured by SwRI) exceed many of these well-established safety temperatures. (See Exhibit A.)

Third, presentations made by Ron Lloyd, an engineer with the Toro Company, and Chris Wannamaker, an engineer with ACS (a major manufacturer of customized muffler systems), explain the logistical constraints and challenges of redesigning equipment with catalyzed muffler systems. These engineers illustrate that there is inadequate space available in most riding equipment applications in which to install the necessary heat shielding and air venting mechanisms that would be required to protect the operator from burns. These experts also explain that the heat shielding typically acts like a screen or fine porous basket. This metallic screen captures dry grass clippings, which remain in contact with the hot muffler surface after the equipment is shut off and parked in a residential garage. (See enclosed Presentation from Ron Lloyd, attached as Exhibit D.) Mr. Lloyd also documents the potential for heavily insulated, catalytic mufflers to auto-ignite gasoline fumes during refueling, particularly if those fumes are pulled inside the hot muffler. In his presentation, Mr. Wannamaker explains the expected rises from catalysts could likely break through the 1350°F threshold. Around this temperature threshold, steel begins to fatigue raising an additional array of safety-related issues.

The remainder of the presentations on the video graphically illustrate the tank deformation, stress cracking and leaks that result from pressurizing plastic fuel tanks and fuel systems at various psi thresholds. These presentations are separately made by Doug Shears, an engineer with Briggs & Stratton, followed by Virgil Huhmann, an engineer with John Deere. (Mr. Shears’ Presentation is attached as Exhibit E.)

Finally, Pete Hotz, Vice President of Engineering Design at Briggs & Stratton, explains the complex and iterative production process under which engine and equipment manufacturers (and their component suppliers, such as catalyst vendors) must design and test new technologies to make sure they can be safely incorporated into non-integrated product lines. (Mr. Hotz’s Presentation is attached as Exhibit F.) Obviously, these product integration challenges are magnified by the fact that there are hundreds of small-equipment manufacturers and component suppliers that will need to work closely together to design, test, and re-engineer hundreds of different emission-compliant and safe products.
III. RECOMMENDED TESTING PROTOCOLS TO EVALUATE HEAT FROM CATALYTIC EXHAUST SYSTEMS

OPEI does not believe that any independent safety studies have ever been conducted to evaluate the safety implications of applying catalysts or pressurized fuel systems to wheeled lawn and garden products (like riding mowers) operating under real-world conditions. Consequently, OPEI would like to coordinate its efforts with U.S. EPA, NASFM and other affected fire and safety stakeholders in designing and implementing a safety study. The needed safety evaluation of catalysts and pressurized fuel systems should specifically evaluate each of the challenging safety risks (described in the attached OPEI Safety Background document) as applied to problematic riding lawn tractors operating under “real world” field conditions. With regard to catalyst viability, the hottest portions of the surface temperature of the representative exhaust and muffler systems and the internal temperature inside the muffler systems must be measured – both in the real world operation of the engine with the catalyst and on a continuous basis from the moment the engine stops operating for at least an additional twenty minutes. In order to be safe, exhaust systems must provide an ample margin of safety with both the surface temperature and the internal muffler/cool-down parameters in all representative muffler systems, including those that are heavily insulated. (See enclosed OPEI Safety Background document.)

IV. CONCLUSION

Through these comments and enclosures, OPEI has tried on short notice to respond with all the information it possesses in order to address the issues raised in your June 1st memo. OPEI and/or OPEI members would like to follow-up these comments by participating in the SAC’s meeting scheduled for July 11th and 12th.

OPEI applauds and strongly supports the ongoing efforts of NASFM to ensure that U.S. EPA obtains all the necessary information in order to reach an appropriate balance between competing environmental and safety goals.

Please contact me directly if I can be of any further assistance.

Sincerely,

William M. Guerry, Jr.

Counsel for the Outdoor Power Equipment Institute

Enclosures
Lawn and garden equipment is typically operated in harsh “field conditions” that pose unique safety risks. Designing products that will (with certainty) be safe under all potential operations conditions is particularly challenging in light of the following constraints. First, lawn and garden equipment remains in direct contact with ignitable grass clippings, leaves and other flammable yard debris during and subsequent to operation. Second, manufacturers must use heat-sensitive plastics and nylon (rather than metal) in the construction of lawn and garden equipment because of space and design constraints and weight. Third, fuel tank and fuel tank opening are inherently very close to the exhaust system on lawn and garden equipment. Fourth, lawn and garden equipment lack the space and the water-based cooling systems associated with automotive-style systems. Fifth, lawn and garden equipment is stored while still hot after use in residential garages. As explained below, many of these challenges are most severe for riding lawn tractors. (See Section V below.)

**OPERATOR CONTACT BURNS**

Obviously, operators of lawn and garden equipment can come in direct contact with the equipment's exhaust surfaces through lifting the enclosed hood, removing debris or grass clippings, refueling, changing the oil, etc. The American Society for Testing and Materials (ASTM) has developed a burn injury standard, C 1055-99, the "Standard Guide for Heated System Surface Conditions That Produce Contact Burn Injuries." The standard specifies that for a metallic surface at 158° F contact skin burns resulting in permanent damage occur almost instantaneously.

**IGNITION OF GRASS CLIPPINGS AND TURF**

Grass clippings, leaves and other flammable yard debris are carried through the air swirling around the cutting blade or similar mechanism and are frequently captured by and retained around the equipment’s exhaust system. No amount of redesign work to “filter” this air flow will keep the flammable debris out of this air stream. In fact, the more extensive the heat shielding or guards around the muffler exhaust system, the greater the propensity for grass clippings to be permanently captured inside the muffler system. For this reason, manufacturers need to carefully monitor and consider the temperatures inside any parts of the exhaust systems where yard debris can collect.

According to the United States Forrest Service's San Dimas Study, grass clippings can ignite at 518 F, particularly in the presence of an open flame. See J-335 Standard for Spark Arrestors. After lawn and garden equipment is turned-off, the equipment continues to radiate heat. This residual heat can draw moisture from turf near or underneath the equipment which results in "turf browning” and can potentially result in ignition of the turf. OPEI member
companies typically require that the residual heat generated from a recently turned-off piece of equipment be less than 150°F to make sure that the equipment does not cause turf browning.

MELTING OR IGNITING FUEL AND SAFETY COMPONENTS

The compact nature of lawn and garden equipment and the close proximity of the nylon or plastic fuel tank, and safety guards to the engine exhaust raise unique heat-related problems. For example, on August 20, 2002, the CPSC announced it was recalling 3,100 professional hedge trimmers because "the catalytic muffler can overheat and damage the fuel tank, posing a fire hazard". CPSC has also recently recalled catalyzed hedge trimmers because the increased heat damaged the muffler’s retaining bolts creating a fire hazard. In the last five years, CPSC has also recalled hundreds of thousands of chainsaws because engine exhaust temperatures threatened to melt the saw's front hand guard.

The functionality of plastic components, including fuel tanks, could be impaired at approximately 150°F, depending on operational stress. The following materials are frequently fabricated into outdoor power equipment parts, such as fuel tanks and internal fasteners: ABS, HDPE and Nylon 6. These materials are functionally impaired (and thus primed to fail or malfunction and possibly cause injury to the operator) at temperatures ranging from 180°F to 279°F (ABS), 140°F to 219°F (HDPE), and 122°F to 388°F (Nylon 6). (.46 Mpa Heat deflection temperature using the ASTM D648 test procedure.) These materials melt and/or burn at temperatures ranging from 475°F to 525°F (ABS), 230°F to 275 °F (HDPE), and 379°F to 491°F (Nylon 6). (Melt temperatures using the ASTM D2117 test procedure).

MUFFLER IGNITION RISKS

In order to ensure that products are well below the operator and fuel system exposure temperature thresholds described above, the manufacturers of catalyzed products would have to develop sophisticated thermal management systems including heat shields and insulated muffler systems. In addition to obvious space constraints (particularly on enclosed riding equipment – see next section), there are complicated safety issues that limit the amount of insulation or shielding that can be added to an exhaust or muffler system. The more insulation shielding provided to the muffler exhaust system to prevent operator contact burns, the greater the propensity for (1) the equipment to retain grass clippings, and (2) for the exhaust system to retain significant levels of heat long after the equipment is shut down. In turn, the longer that the muffler exhaust system remains hot, and in contact with the captured grass clippings, the greater the risk that there could be fires or explosions during refueling or fires caused by grass burning after the equipment shuts down.

Under the same general operating conditions, an insulated or tightly shielded muffler system with catalysts could run several hundred degrees hotter than a non-insulated and non-catalyzed muffler and take much longer to cool down to temperatures which are appropriate and safe for refueling. If the surface inside the muffler exhaust system remain above roughly 830°F one minute after the product shut downs and is refueled, then there is a risk that the fumes from the gasoline vapors could be sucked into the muffler system and be ignited in a violent explosion.
that could produce severe fire and burn hazards to the operator and bystanders in the vicinity of the equipment. A larger and hotter catalyzed muffler system could consume the current safety margin between the temperature of the muffler during refueling and the 830°F auto-ignition temperature of gas fumes.

Because of the close proximity of the lawn and garden equipment's fuel tank opening to the engine's exhaust system, it is difficult to redesign equipment to address this risk. (See next section.) No amount of operator training and video training will fully eliminate the probability of refueling events occurring sooner than the manufacturer would desire. For this reason, the CPSC has been involved with several different recalls of thousands of lawn and garden equipment based on the potential re-ignition of refueling vapors in the product's muffler system.

ADDITIONAL CHALLENGES WITH RIDING LAWN TRACTORS

Fire hazards with riding lawn tractors are more common than with walk behind mowers because: (1) the engine, muffler and gas tank are substantially bigger and in case of a fire, create more heat and a bigger fire; (2) bigger machines are used in higher grass and fields with dry grass and leaves; and (3) dry grass and leaves can be ignited by a hot muffler and can create a fire if gasoline is spilled when filing the gas tank. The operator can be burned seriously in cases where gasoline is not only spilled on the mower, but also spilled on the operator. The 1998 CPSC hazard analysis shows that 5% of the riding mower deaths are fire related.

Most mufflers are presently located in front of the tractor below the grille and the engine. This way, the muffler does not overheat the engine underneath the hood. Exhaust fumes are farthest away from the operator. The engine airflow blows air over the muffler to cool the muffler when the engine is running. Present muffler temperatures are in the approximate 650°F to 760°F range. Catalytic converters with substantially higher exhaust temperatures could bring the exhaust system temperature above the ignition temperature of dry grass, leaves and gasoline.

Moving the catalytic converter for lawn tractors in an area where it will not ignite dry grass leaves and gasoline would be complicated and expensive because a new position for the muffler is needed which has to be harmonized with each engine, hood and grille design.