

FIRE EXPOSURES OF FIREFIGHTER SELF-CONTAINED BREATHING APPARATUS FACEPIECE LENSES (NIST TECHNICAL NOTE 1724)

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■ PERSONAL PROTECTIVE EQUIPMENT

EMERGENCY FIRST RESPONDER RESPIRATOR THERMAL CHARACTERISTICS: WORKSHOP

A diverse group of experts in SCBA manufacturing, certification testing, use, and research was assembled to discuss and identify needs and research priorities related to emergency responder respirators. The first goal of the workshop was to review the current state-of-the-art of SCBA technology and identify critical performance needs. One performance need defined by the workshop included the thermal resistance of the facepiece equal to or better than the rest of the fire fighter ensemble.

■ SYNOPSIS:

Respiratory protection, in the form of Self-Contained Breathing Apparatus (SCBA), is a vital component of a firefighter's Personal Protective Equipment (PPE). The SCBA facepiece lens is often considered the weakest component of a fire fighter's ensemble in high heat conditions, but the level of thermal performance of the facepiece lens is not well understood.

Thermally degraded and melted SCBA facepiece lenses have been identified as a contributing factor in certain firefighter fatalities. The Fire Exposures of Firefighter Self-Contained Breathing Apparatus Facepiece Lenses study demonstrated a range of realistic thermal exposures and environmental conditions which can result in thermal degradation and even catastrophic failure of facepieces.

The tests conducted as part of the study consisted of a series of six (6) live fire experiments, utilizing eight (8) different facepieces with five (5) different models. The fires, lasting between 5 to 10 minutes, produced a ceiling temperature of approximately 500 °C (932 °F) to 750 °C (1382 °F) in the monitoring room adjacent to the fire.

All facepieces were fitted with a heat flux (the amount of heat being transferred across a surface) gauge and exposed to thermal environments either from propane-fueled equipment or live fire from a commonly furnished townhouse setup. A constant airflow at 40L/min, to simulate breathing, was introduced into three (3) of the facepieces.

Of the eight facepieces tested, three facepieces lenses demonstrated evidence of thermal degradation from the exposure.

While thermal degradation of SCBA facepieces' lenses was shown to begin when the temperature exceeded the lower end of the melting temperature range for polycarbonate (which make-up the facepiece lens), heat flux peaks in excess of 20 kW/m² always resulted in degradation that would adversely affect the firefighter.

While further study will be needed, the fire service should view this data as a valuable first step in understanding and preventing firefighter injuries and fatalities associated with SCBA equipment failure. This data will set the course for future studies that will prove beneficial in developing specifications for SCBA facepieces, as well as policy and procedural development regarding SCBA use, inspection, maintenance, and replacement intervals.



■ FINDINGS:

- **Brand of facepiece not a factor.** There was no observable difference in the performance of the facepiece between the different models used.
- **Shape may be a factor.** While further study is needed, the geometry and construction of the facepiece and polycarbonate lens may be a factor in facepiece lens degradation.
- **Airflow provides cooling.** The effect of air flowing in the mask produced, in some cases, a slight cooling effect between the interior and exterior surfaces of the facepiece.
- **Degradation unavoidable.** Once a polycarbonate reaches its glass transition temperature (becoming soft and pliable), it will begin to lose all integrity and will become vulnerable to physical impact.
- **Temperature versus Heat Flux.** Conditions that caused facepiece lens bubbling, loss of visual acuity and even breach of the facepiece always involved peak levels of heat flux in each of the facepieces. The lower melting temperature range varied.

■ TAKEAWAYS:

- This study is the first step in identifying the causative factors regarding material degradation of SCBA facepiece lens. This testing reveals the expected limits to the integrity of SCBA facepieces lens based on temperature environments and heat flux.
- There is a failure limit to all materials used in the manufacturing of SCBA facepieces.
- While an SCBA is provided to allow entry into IDLH environments, training and situational awareness are the most important factors in assuring that an SCBA facepiece does not reach failure point.
- Firefighters should be educated on the thermal and heat flux limits of SCBA facepieces and understand the importance of proper use, inspection and maintenance after any thermal exposure.
- The fire service must keep abreast of future research projects that address:
 - the effects of both thermal and heat flux exposure on SCBA facepieces
 - an understanding of the importance of SCBA facepiece use and maintenance
 - the consequences of a catastrophic failure of a SCBA facepiece



Typical fire-fighter breathing apparatus damaged in NIST tests shows facepiece warping under high heats.

While this report provides vital data regarding approximate temperatures and heat flux environments that will cause a facepiece lens to degrade, further experiments are needed to identify not only these circumstances but other influences that cause facepiece failures. Data on the restrictions of the SCBA facepiece would be valuable information for the fire service to help prevent further injuries and fatalities related to SCBA facepiece failure.

■ FIRE STATION TALK

Start a conversation about the study. Be a leader and be prepared to talk from a knowledgeable point of view. All members of the organization will require an understanding of what the science and research are telling us. Stress the importance of a thorough safety equipment inspection. It's not just your safety; it's everyone's safety that cannot be minimized. Every shift or duty assignment requires inspection of your SCBA facepiece; it is a critical part of your equipment. NFPA states that the one of the more fragile parts of your PPE is the facepiece lens. Review the fact sheet for firefighters, talk about the NFPA standard and your department policies related to PPE and SCBA.

- Review the vital components of a facepiece and perform the inspection.
- Inspect the facepiece seal and other rubber components for deformation, wear, damage or cracks.
- Inspect the lens for cracks, gouges, scratches or any condition that could impair the operation of the facepiece or the user's vision.
- Inspect the lens frame for damage such as cracks or distortion.
- Check that all lens frame retainers are present and installed correctly.
- Check that all harness anchors are present and pivot freely.
- Inspect the head harness for correct installation with all straps oriented correctly.
- Inspect the head harness for damage or worn components.
- Inspect the nosecup.

■ CHIEF'S PERSPECTIVE

- Empower personnel to understand the need for safety
- NIST conducted experiments (with the support of the Chicago Fire Department, the Department of Homeland Security, and the U.S. Fire Administration) which demonstrated a range of realistic thermal exposures and environmental conditions that firefighters could be exposed to.
- Develop realistic process for budgeting that recognize the rapidly changing safety standards and allows for implementation of safer equipment upgrades.

■ NIST STUDY AND REPORT

- Emergency First Responder Respirator Thermal Characteristics: Workshop Proceedings http://www.nist.gov/manuscript-publication-search.cfm?pub_id=908782
- NIST Technical Note 1724 Fire Exposures of Fire Fighter Self-Contained Breathing Apparatus Facepiece Lenses http://www.nist.gov/customcf/get_pdf.cfm?pub_id=909917