NOISE LEVEL HAZARD ACOUSTICAL TESTING REPORT

Introduction: Over the past several years, personal protective equipment (PPE) has been developed to protect workers from the intense radiant heat energy of an electric arc flash event. Oberon arc flash suits, including hoods and hood shield windows, are available with heat protection levels up to 100 cal/cm^2. However, there is increasing concern among some members of the NFPA 70E Technical Committee regarding potential hazards other than heat exposure that are also part of an electric arc event, e.g. shrapnel, pressure waves and high sound levels. The NFPA 70E Technical Committee elected to limit its Hazard/Risk Category exposure levels to 40 cal/cm^2 in the proposed 2004 edition until a better understanding of these additional arc flash hazards is achieved.

DuPont conducted tests in the late 1990s on sound levels produced by an arc flash event. Oberon has conducted limited testing in the area arc flash sound reduction due to Oberon's existing PPE product line. This report provides a summary of this testing.

Description of the Arc Flash Event: An electric arc flash event consists of a complicated series of hazards primarily originating from the nearly instantaneous generation of an atmospheric plasma. These hazards include a radiant heat exposure, a pressure or "shock" wave, an excessive noise exposure, molten metal splatter (from the plasma erosion of the conductors and nearby materials), and ejection of projectiles or bits of "shrapnel" accelerated by the explosive force of the plasma formation.

Sound Level in an Arc Flash Event: Measurements of multiple three-phase arc events show noise levels increase with increasing arc fault current. This effect would be expected since the noise hazard most likely results from the initial explosive expansion of air and formation of a plasma region between conductors. The first half cycle of the arc tends to produce the "big bang". Subsequent cycles serve to maintain the plasma, due to continuous current flow during a three-phase arc, and would not be expected to prolong the initial noise level. The sound level measured at a distance of six feet from the source of the arc flash with fault currents from 5 to 30kA were observed to be extremely high ranging from 140 to 165 dB. This noise level is sufficient to cause damage to hearing in a single event.

Sound Level Hazard Versus Heat Exposure in an Arc Flash Event: Because the sound level is related to the fault current on the first half cycle of the arc flash and heat exposure is related to both fault current and the duration of the arc flash, the hazard analysis used for heat exposure cannot be used for the sound level hazard. For instance, it is possible to have a very short arc flash duration of a half cycle but with a high fault current of 100kA that would have a very high sound level but a relatively low heat exposure. Conversely, we could have a long duration arc flash event of 60 cycles (1 second) with a low fault current of 8kA that would have a low sound level but a very high heat exposure.

The importance of this is that until we have an independent method of sound level hazard analysis, the worker needs to use hearing protection at all heat exposure levels.

Acoustical Testing Results for Oberon Arc Flash PPE: Oberon has conducted Acoustical testing on its products in February of 2004. The results shown in Table 1 indicate that PPE can significantly attenuate the sound hazard, but since the sound level for and arc flash event is so high, the worker still needs to use hearing protection. The results show that the sound protection provided by PPE generally increases as the Arc Rating of the PPE increases. Since a 6 dB reduction represents a 50% reduction in sound level, this testing indicates that with the sound projected directly into the ear through the hood fabric an ARC100 hood would reduce the sound level by approximately 75%. If the sound is projected directly at the hood shield window, i.e. at 90° to the ear canal, the sound reduction would be approximately 90%. Earmuff type hearing protection alone reduces sound by 97%.

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Test Set #1 Speaker in Same Plane as Ear, Sound Waves Projecting Into Microphone Opening (except as noted)	
Test Item Description	**Sound Level, (dB)**
Bare, no covering, 0^{O}	125
ARC15	118.9
ARC25	121.9
Bare, no covering	124.9
ARC31	114.2
ARC40	120.8
Bare, no covering	125.3
ARC50	117.4
ARC65	112.9
ARC100	113.3
ARC100B	110.7
Bare, 0^{0}	125.6
Bare, 33^{O}	124.5
Changed to 90^{O}	Orientation
Bare, 90^{O}	122.4
Bare, no covering[1], 90^{O}	123.7
Bare, no covering[1], 90^{O}	124.6
Bare, no covering[1], 90^{O}	124.9
ARC15 Frontal	112.2
ARC15 w/Ear Protection	92.9
ARC15 Backwards	120.25
ARC25 Frontal	115.9
ARC25 w/Ear Protection	94.4
ARC25 Backwards	122.1
ARC31 Frontal	109.3
ARC31 w/Ear Protection	90.5
ARC31 Backwards	116.9
ARC40 Frontal	114.6
ARC40 w/Ear Protection	93.2
ARC40 Backwards	122.1

Test Set #2 Speaker @ 90^{O} to Plane of Ear, Sound Waves Projecting @ 90^{O} to Microphone Opening	
Test Item Description	**Sound Level, (dB)**
Bare, no covering[1], 90^{O}	124.9
ARC15 Frontal	112.2
ARC25 Frontal	115.9
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ARC31 Frontal	109.3
ARC40 Frontal	114.6
ARC50 Frontal	110.2
ARC65 Frontal	106.3
ARC100 Frontal	105.2
ARC100B[5] Frontal	105.6
Final Test, Bare, 90^{O}	124.2
Ear Protection[2] 90^{O}	93.96
ARC8 FaceShield[3] 90^{O}	116.4
ARC15 FaceShield[4] 90^{O}	120.0
ARC50 Frontal	110.2
ARC50 w/Ear Protection	92.3
ARC50 Backwards	118.5
ARC65 Frontal	106.3
ARC65 w/Ear Protection	90.8
ARC65 Backwards	117.0
ARC100 Frontal	105.2
ARC100 w/Ear Protection	89.6
ARC100 Backwards	114.1
ARC100B[5] Frontal	105.6 &105.5
ARC100B[5] w/Ear Protection	88.3
ARC100B[5] Backwards	114.8

[1] Sound levels were increased to maintain 125 dB. A decrease in 6 dB is equivalent to reducing the sound level by 50%.
[2] Hearing Protection was protective ear muffs from Willson 666/665A, Reading, PA.
[3] ARC8 "H" Batch H-080205 Proprionate Face Shield with chin guard.
[4] ARC15 "5L" Batch 0703L1 Polycarbonate Face Shield was removed from hood, tested w/o chin guard.
[5] The ARC100B Hood had a second shield window consisting of clear polycarbonate.

Table 1 Oberon Sound Testing Results

Acoustical Testing Conditions:

- All testing was conducted at Compliance Management Group, N. Billerica, MA.
- Sound levels were created by amplifying a recording of an arc flash event from a VHS videotape.
- Sound levels used at 125 dB are lower than actual arc flash sound levels (140 to 165 dB).
- The mannequin head from the Drop Test XXX was fitted with an acoustical research grade microphone (model #).
- Test Set #1 was conducted with the mannequin head turned sideways to speaker so that the maximum sound would enter the microphone. The microphone positioned 10 inches from front plane of speaker and at the midpoint of the speaker height which was 18 inches from the bottom of the speaker.
- Test Set #2 was conducted with the mannequin head turned toward the speaker so that sound waves were 90^{O} from the plane of the microphone opening. Sound levels were increased slightly to maintain 125 dB in this configuration. The microphone positioned 10 inches from front plane of speaker and at the mid point of the speaker height which was 18 inches from the bottom of the speaker.
- Data acquisition time was 30 seconds.
- Tests conducted in an "AN-ECK-OIC" Hemi-Anechoic Chamber with all surfaces non-reflective except floor. Chamber manufactured by Eckel Industries of Canada, Ltd., Morrisburg, Ontario.
- Protective earmuffs were used on some tests, earmuffs were Willson 666/665A, Reading, PA.