

<b>Fiscal Year:</b>	FY 2009	<b>Task Last Updated:</b>	FY 01/20/2009
<b>PI Name:</b>	Koscheyev, Victor S Ph.D.		
<b>Project Title:</b>	Test and Evaluation of Liquid Cooling Garments		
<b>Division Name:</b>	Human Research		
<b>Program/Discipline:</b>	HUMAN RESEARCH		
<b>Program/Discipline--Element/Subdiscipline:</b>	HUMAN RESEARCH--Operational and clinical research		
<b>Joint Agency Name:</b>	<b>TechPort:</b>	No	
<b>Human Research Program Elements:</b>	(1) <b>HHC:</b> Human Health Countermeasures		
<b>Human Research Program Risks:</b>	(1) <b>EVA:</b> Risk of Injury and Compromised Performance Due to EVA Operations		
<b>Space Biology Element:</b>	None		
<b>Space Biology Cross-Element Discipline:</b>	None		
<b>Space Biology Special Category:</b>	None		
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<b>Zip Code:</b>	55455	<b>Congressional District:</b>	5
<b>Comments:</b>			
<b>Project Type:</b>	GROUND	<b>Solicitation / Funding Source:</b>	Directed Research
<b>Start Date:</b>	06/01/2007	<b>End Date:</b>	12/31/2008
<b>No. of Post Docs:</b>	1	<b>No. of PhD Degrees:</b>	1
<b>No. of PhD Candidates:</b>	1	<b>No. of Master' Degrees:</b>	
<b>No. of Master's Candidates:</b>		<b>No. of Bachelor's Degrees:</b>	
<b>No. of Bachelor's Candidates:</b>	16	<b>Monitoring Center:</b>	NASA JSC
<b>Contact Monitor:</b>	<b>Contact Phone:</b>		
<b>Contact Email:</b>			
<b>Flight Program:</b>			
<b>Flight Assignment:</b>	NOTE: Received NCE to 12/31/2008 (from 12/31/2007) per PI (3/08) NOTE: Received NCE to 3/31/2008 per PI (12/07)		
<b>Key Personnel Changes/Previous PI:</b>			
<b>COI Name (Institution):</b>	Leon, Gloria R. ( University of Minnesota )		
<b>Grant/Contract No.:</b>	NNX07AI90A		
<b>Performance Goal No.:</b>			
<b>Performance Goal Text:</b>			

<b>Task Description:</b>	<p>This research evaluated the physiological functioning and subjective comfort of subjects while donned in each of five liquid cooling garments. The goal was to identify the optimal features of each of the garments to maintain core temperature and comfort under intensive physical exertion. Four males and 2 females between the ages of 22 and 46 participated in this study. The garments evaluated were the Minnesota Advanced Cooling Suit (MACS-Delphi), Russian Orlan, NASA LCVG, MACS-Delphi without hood, and Russian Orlan without hood. Subjects were tested on different days in 2 different environmental chamber temperature/humidity conditions (24oC/H-28%; 35oC/H-20%). Each session consisted of stages of treadmill walking/running (250W to 700W at different stages) and rest. Skin and core temperatures, energy expenditure, heart rate, evaporative/nonevaporative sweat rate, and ratings of thermal comfort and heat sensation, overall and on specific body areas were measured throughout each session. There were significant differences among garments in femoralis temperature (<math>p&lt;0.001</math>), and calf temperature (<math>p&lt;0.05</math>); the LCVG was lowest in temperature on these areas. In general, the findings showed few consistent differences among the garments. The MACS-Delphi was better able to maintain subjects within a skin and core temperature comfort zone than was evident in the other garments as indicated by a lesser fluctuation in temperatures across physical exertion levels. The LCVG provided the greatest amount of cooling, in some conditions this resulted in body overcooling as noted in declines in skin temperature below a comfort level. Subjective ratings of thermal comfort were higher in the MACS-Delphi. Physiological findings comparing garments with and without the hood were inconclusive; however, subjects rated both the MACS-Delphi and the Orlan with hood as higher in overall thermal comfort.</p>
<b>Rationale for HRP Directed Research:</b>	
<b>Research Impact/Earth Benefits:</b>	The findings of this research have application for optimal designs of cooling garments for firefighters, those donned in HAZMAT suits, and for military personnel active in extremely hot or cold environmental conditions.
<b>Task Progress:</b>	<p>This testing project has been completed and suggests that the design of cooling garments for lunar and Mars exploration in which considerable physical exertion is required can be enhanced by following principles of physiological design. The placement of garment tubing on body areas that are highly effective in transferring heat showed the greatest effectiveness in maintaining skin and core temperature within a physiological and subjective comfort zone. The findings also indicated that it is not necessary to induce excessive cooling through the garment to control core temperature during intense physical exertion. The garment with less but strategically placed tubing (MACS-Delphi) was rated by subjects as having both greater thermal and physical comfort, and also rated as more flexible during movements simulating exploration activities such as bending and kneeling. The findings were inconclusive regarding thermal stability with the inclusion of a hood vs. no hood.</p>
<b>Bibliography Type:</b>	Description: (Last Updated: 02/07/2014)
<b>Papers from Meeting Proceedings</b>	<p>Koscheyev VS, Lee J-Y, Kim J-H, Leon GR, Kwon S, Gernhardt ML. "Cooling and thermal control strategies in the space suit for routine and emergency situations." 38th International Conference on Environmental Systems, San Francisco, Calif., June 30-July 3, 2008.</p> <p>Proceedings of the 38th International Conference on Environmental Systems. SAE Technical Paper Series 2008-01-1993. Warrendale, PA : SAE International, 2008. , Jul-2008</p>