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Extreme Temp Effects

RESEARCH ARTICLE:

EXTREME TEMPERATURE EFFECTS ON BLOODSTAIN PATTERN ANALYSIS

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INTRODUCTION

The shedding of blood at violent crime scenes can provide significant information to assist the crime scene investigator in reconstructing fatal and non-fatal events. It is this examination of blood through "Bloodstain Pattern Analysis" that the investigator can work in concert with other disciplines of forensic science to verify or contradict a version of events provided by the suspect or witnesses. Bloodstain pattern analysis can also assist with determining where the victim was at the time of bloodshed, movement and directionality of persons or objects while blood is being shed, the number of blows received by a victim, an area of origin of that blood, and type and direction of impact. Individual bloodstains can be examined for size, shape, distribution and orientation (James, 1999). Measuring the width and length of well-formed bloodstains, and determining the arc sin through basic trigonometric functions on a calculator, can establish an impact angle. Utilizing angles of impact for several bloodstains in concert with their distances from an origin on a two-dimensional plane, an area of origin in space where the blood originated can be established. This area can be realized through the use of a protractor and string to project the angles from the stain. A three dimensional model is then constructed allowing one to visualize the area in space away from a horizontal or vertical surface (MacDonell, 1997).

The crime scene examiner often works in less than ideal conditions when attempting to reconstruct violent events. Scenes where blood has been shed occur in environments that are exposed to extreme temperatures. Research has been conducted on the effects of fire (extreme heat) on bloodstain patterns as well as observations recorded of stains at crime scenes in freezing environments. In both instances, the bloodstains generally retained their characteristics and remained suitable for interpretation (Eckert and James, 1993).

Although the effects of heat and cold on bloodstain patterns have been observed to some degree, comprehensive research does not appear to have been published which explored the effects of extreme temperature ranges on common non-porous surfaces. A review of research to date failed to locate published articles on the effects of both extreme temperatures ranges (heat & cold) on bloodstain patterns and subsequent interpretation. When non-porous surfaces are exposed to extreme cold and heat within ranges that could conceivably be found regionally, can directionality, angle of impact and area of origin be accurately determined? Does blood react differently when exposed to extreme temperatures than it does in normal ranges (ambient temperature) in appearance and drying times? This project attempted to address these questions to further assist in the interpretation of bloodstain patterns produced in violent crime.

MATERIALS AND METHODS

Four different nonporous surfaces (painted drywall, linoleum flooring, ceramic tile and glass) were utilized to represent a wall, floor and window for 3 different temperature ranges and for 5 different types of bloodstains (36 surfaces total). Drywall and linoleum flooring were utilized as the primary surfaces whereupon directionality, point of convergence and impact angles were examined. The remaining surfaces were utilized for general comparison to the directionality of blood on drywall and linoleum.

Pieces of drywall measuring 2 x 2 feet were painted on one side with Duron White Flat Vinyl Acrylic Latex paint applied with a paintbrush. Sections of linoleum flooring were cut into sections measuring approximately 18 x 18 inches and stapled onto slightly larger pieces of plywood. Sixteen white ceramic wall tiles (6 x 6 inches) were mounted on a 2 x 2 feet piece of plywood utilizing commercially available tile adhesive and pre-mixed grout. For those sections designated for high velocity experiments, the tiles were placed around a drilled opening measuring approximately 6 inches in diameter. The smooth glass panes, measuring 12 x 12 inches, were utilized without a mounting, though a clear laminate was placed on one side (back) of the glass for the high velocity experiments.

1: A standard 24W x 20H x 48L (inches) cardboard wardrobe box was utilized during high and medium velocity experiments (Figure #1). This allowed the target surfaces to be secured within the box and contain bloodspatter. A wooden pole was placed across the open top end of the box and a clamp attached to secure a piece of sponge with cardboard backing for use during the high velocity experiments. Upon disposal of the wardrobe box due to contamination, a cardboard box of lesser proportion was utilized in the same fashion. The panes of glass were also suspended from the clamp for the high and medium velocity experiments.

2: A wooden containment chamber was constructed for use during the high temperature experiments (Figure #1). This box was lined with aluminum and a clear plastic covering supported by a plastic tent frame was used as a top covering to trap the heat. A space was left at one end for the placement of the firearm during high velocity experiments.

3: A laser guided hand held infrared thermometer along with a standard mercury and digital thermometer (which also recorded humidity) were utilized to record substrate, air within the controlled environments and ambient temperatures.

4: A mechanical mousetrap was utilized to simulate medium velocity bloodspatter. The center bar was taped to provide a surface that could impact blood placed directly on the mousetrap bait area (metal bait holder removed).

5: Tissue and surgical cloth were utilized for the creation of swipe and wipe bloodstains.

6: Disposable pipettes were utilized to release droplets of blood onto target surfaces.

7: Four standard 10ml vaccutainer vials with an anti-coagulant were utilized for blood storage upon withdrawal from a human subject, drawn immediately before dispersal. Blood once drawn was kept at body temperature until used for any given experiment.

8: A 9mm Sig-Sauer P228 semi-automatic handgun with 9mm military ball ammunition.

Terminology

Low Velocity Stains: Typically seen with venous bleeding, the effects of natural blood flow. Generally any non-spatter pattern, stains at least 4mm or larger in diameter. Resulting from normal gravitational forces or actions up to 5ft/s (swipes, wipes, drops).

Swipe: Transfer of blood onto an unstained surface by movement of a bloodstained object.

Wipe: Unstained object moves through an existing stain.

Medium Velocity Stains: Produced by impact with an instrument like a hammer or club. The preponderant bloodstains being between 1mm to 4mm in size, though bloodstains may also be produced which are smaller, the result of energy between 5 and 25ft/s.

High Velocity Stains: Classically produced by injury from a firearm. The preponderant of the bloodstains being 1mm or smaller, the result of energy in excess of 100ft/s (Bevel and Gardner, 1997).

A total of 5 different types of bloodstains were prepared on the 2 primary surfaces (drywall, linoleum) at 3 different temperatures. These surfaces were selected as they represent a wall and floor, common surfaces found at crime scenes. It was noted that the linoleum had ridges and valleys, or more specifically a "dimpled" texture. Glass and tile were utilized for general comparison to the directionality of blood on drywall and linoleum. The bloodstains were examined as low velocity, drops at a known angle, a swipe, a wipe, medium and high velocity spatter.

The target surfaces were subjected to temperature ranges representing extreme cold, ambient, and extreme hot. The subsequent non-microscopic changes that occurred to the blood were recorded along with a range of drying times for each primary surface. Additionally, the point of convergence for the stains selected was constructed along with impact angles for those stains and the area of origin for the two primary target surfaces.

The point of convergence represents the location on a two-dimensional plane whereupon the blood was shed. Projected out from this point on a three-dimensional axis would provide an area of origin of that blood. This was determined by the "Tangent Method", a calculation achieved by using the tangent of the angle of impact multiplied by the distance of a specific stain from the point of convergence. This method is an acceptable alternative to using strings. It is important to note that the actual "area of origin" is in fact that, an area in space that is at or below the location indicated by the tangent method. A specific "point" of origin will not be determined. As the investigator may only be looking to determine if the victim was lying or standing at the time of bloodshed, this approximation is not a detriment to scene reconstruction (MacDonell, 1997).

The first experiment consisted of the placement of several droplets (0.05ml drop) of blood via a pipette onto a target surface positioned at a 45-degree angle. The second experiment created a "swipe" bloodstain by moving a blood soaked tissue or cloth over the target surface. The third experiment created a "wipe" bloodstain by moving a tissue or cloth through blood previously deposited on the target surface. The fourth experiment created a medium velocity bloodstain pattern on the target surface using blood dispersed by a mousetrap. The fifth experiment created a high velocity bloodstain pattern utilizing a 9mm handgun with ball ammunition fired through a blood soaked sponge suspended in front of the target surface. The Prince George's County Police, MD, firing range was utilized for the high velocity experiments. Drying times were determined by observation and touch.

RESULTS & OBSERVATIONS

Experiment Series I

The first series of experiments were conducted with painted drywall surfaces in cold, ambient and hot temperatures. Dripped blood, wipes, swipes, medium velocity and high velocity bloodstains were created. Surfaces D-1 and D-4 were created in a bulk storage freezer. D-7 was created at an outdoor firing range in January 2000. The hot temperatures were attained (July 2000) within a specially constructed chamber that was previously discussed in the "Materials and Methods" section. Recorded temperatures were rounded off to the nearest degree. Due to requirements for high velocity experiments in the cold range (firearm discharge), an outdoor firing range was utilized in the winter. This experiment should be repeated if an accurate comparison of drying times is to be considered, as the desired temperature was not attained (below 32 deg. F).

Cold Temperature (F)

Stain	Drywall	Air Temp Humidity	Surface Temp	Start Time	Initial Freeze or Dry Time[1]	End Freeze - Dry Time & Final [2]
Drops	D-1	23/56%	27°	11.16	11.17	11.20/4m
Wipes	D-1	23/56%	27°	11.18	11.22	11.25/7m
Swipes	D-1	23/56%	27°	11.23	11.25	11.25/2m
Medium	D-4	23/56%	18°	12.25	12.58	12.58/33m
High	D-7	43/56%	N/A	8.59	9.05	9.21/22m

Ambient Temperature (F)

Stain	Drywall	Air Temp Humidity	Surface Temp	Start Time	Initial Dry Time	Dry Time & Final
Drops	D-2	72/67%	71°	1.34	1.40	3.25/111m
Swipes	D-2	72/67%	71°	1.36	1.39	1.39/3m
Wipes	D-2	72/67%	71°	1.36	1.38	1.38/2m
Medium	D-5	72/67%	71°	2.42	2.45	3.19/37m
High	D-8	79/68%	78°	10.29	10.31	10.37/8m

[1] Represents the time freezing/drying was initially observed throughout the individual stain or pattern.
[2] Represents a range of times as observed for stains to completely freeze. Checked at intervals in freezer. Found completely frozen by touch of gloved hand as indicated by final time.

Hot Temperature (F)

Stain	Drywall	Air Temp - Humidity[3]	Surface Temp	Start Time	Initial Dry Time	Dry time & Final
Drops	D-3	110/92/72%	102°	4.07	4.29	4.29/22m
Wipes	D-3	110/92/72%	102°	4.07	4.12	4.12/5m
Swipes	D-3	110/92/72%	102°	4.07	4.09	4.09/2m
Medium	D-6	112/92/72%	115°	2.55	2.56	2.56/1m
High	D-9	109/92/72%	113°	1.53	1.54	1.54/1m

Upon immediate examination of the drywall substrates when removed from the extreme cold environment, individual bloodstains had a frozen, crystal like appearance. After several minutes in ambient temperature (72 deg. F), the drips and wipes, placed at a 45-degree angle, started to thaw and run down the substrates. The outline of the original stain was preserved regardless of thawing. Upon general examination of the surfaces when placed side by side, the bloodstains were dark red in appearance from the cold experiment, less dark red/brown in the ambient range and a light red/brown in the hot range. This variance in color "may" be associated with drying times and/or aging of the bloodstains. Further experimentation on blood drying times in these temperature ranges is required before this question can be answered definitively. Bloodstains on all surfaces showed directionality and well-formed bloodstains were present on all surfaces. Upon magnification, the bloodstains showed a characteristic drying appearance, flaking and skeletonized stains with distinct cracks through the more dense part of the stain. The larger stains (>2mm) in D-4 (medium) and D-7 (high velocity) took 33 and 22 minutes to dry respectively in the cold range. D-2 (drops) and D-5 (medium velocity) took 111 and 37 minutes to dry respectively in the ambient temperature. In the hot temperatures, D-3 (drops) took the longest to dry at 22 minutes.

Experiment Series II

The second series of experiments was conducted with linoleum flooring, cut into sections and stapled onto a piece of plywood. The substrates were exposed to the same temperature ranges as in series 1. Recorded temperatures were rounded off to the nearest degree. Due to requirements for high velocity experiments in the cold range (firearm discharge), an outdoor firing range was utilized in the winter. This experiment should be repeated if an accurate comparison of drying times in the cold range is to be considered as desired temperature was not attained (32 deg. F).

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[3] The experiment was conducted outside in a specially constructed chamber. The higher temperature is the temperature inside the chamber. The second temperature is the outside air temperature.

Cold Temperature (F)

Stain	Linoleum Floor	Air Temp Humidity	Surface Temp	Start Time	Initial Dry Time	Dry Time & Total
Drops	L-19	23/64%	26°	12.56	1.09	2.23/87m
Wipes	L-19	23/64%	26°	12.56	1.09	1.14/18m
Swipes	L-19	23/64%	26°	12.56	1.09	1.14/18m
Medium	L-22	10/64%	18°	1.12	1.13	2.15/63m
High	L-25	43/68%	43°	9.28	9.33	9.50/22m

Ambient Temperature (F)

Stain	Linoleum Floor	Air Temp Humidity	Surface Temp	Start Time	Initial Dry Time	Dry Time & Total
Drops	L-20	72/67%	71°	1.51	1.54	1.59/8
Swipes	L-20	72/67%	71°	1.52	1.56	1.59/7
Wipes	L-20	72/67%	71°	1.53	1.56	3.24/91
Medium	L-23	72/67%	70°	2.28	2.31	3.29/61
High	L-26	79/65%	N/A	10.23	10.49	10.49/26

Hot Temperature (F)

Stain	Linoleum Floor	Air Temp Humidity	Surface Temp	Start Time	Initial Dry Time	Dry Time & Total
Drops	L-21	112/92%	113°	3.37	3.50	3.50/13m
Wipes	L-21	112/92%	113°	3.37	3.50	3.50/13m
Swipes	L-21	112/92%	113°	3.37	3.38	3.50/13m
Medium	L-24	112/92%	113°	3.03	3.04	3.15/12m
High[4]	L-27	110/92%	113°	1.43	1.45	1.47/4m

[4] Fine mist produced by high velocity impact appeared to dry almost immediately. Larger stains (>2mm) were observed for initial drying times.

Upon examination of the linoleum flooring removed from the cold temperature, the stains had a crystal frozen like appearance as observed for stains in the drywall cold tests. Once L-19 (drops and wipes) were removed from the freezing environment and placed at a 45-degree angle in ambient temperature (72 deg. F), the stains began to thaw and several larger (>2mm) bloodstains ran into others. Less running of stains was present on the linoleum than the drywall. The original outline of the impact stain appeared to be preserved regardless of thawing and subsequent drying. The larger stains on the flooring took a long time to freeze in the cold environment as well as in the ambient range. L-19 (drops) took 87 minutes to dry in the cold range, and L-22 (medium velocity) 63 minutes. L-20 (wipes) and L-23 (medium velocity) in the ambient range took 91 and 61 minutes to dry respectively. In the hot range, the drying times for all surfaces were between 4 and 13 minutes.

After being allowed to dry after thawing, the larger bloodstains (L-19) had a distinct fracture/demarcation line across the wide axis of the stain. There were parallel fracture lines obvious in the dense portion of these large stains, running from the center outward in both directions. Well-defined stains were present in the medium and high velocity range. Upon magnification, stains had a characteristic drying appearance, skelotonized with a dark red/brown appearance. The darker stains were on the cold surface, a lighter red/brown color to the stains in the ambient range and the lightest red/brown in the hot range. The color variance may be due to the aging and/or drying of the stain; further experimentation is required before this can be answered definitively. The linoleum flooring is most likely chemically treated to prevent staining and absorption of liquids. This process may have an effect on the reaction of fluid on the surface, possibly increasing drying times. Further inquiry is demanded in this regard.

Impact Angle Determination:

Two well-defined bloodstains were selected (A and B) for measurement on low velocity surfaces D-1 through D-3, and L19 through L-21. The known angle was 45-degrees. Two separate examiners measured the stains. The average of the angles was utilized for comparison. D-1 through D-3 calculations resulted in a range from 43.4 to 45.4 degrees. L-19 through L-21 calculations resulted in a range from 44 to 47.2 degrees (Figure #2).

Formula: arc sin of $\frac{\text{width of bloodstain}}{\text{length of bloodstain}}$ = impact angle

Point of Convergence & Area of Origin:

Five individual bloodstains (A-E) were selected on medium and high velocity surfaces D-4 through D-9, and L-22 through L-27. The two-dimensional point of convergence was constructed by placing string through the long axis of the stain. The distance from each marked bloodstain to the convergence point was measured; the area of origin was calculated utilizing the Tangent Method and compared to the approximate location of blood dispersal (4 inches & 9 inches away from target). The area of origin was calculated in an accepted range of 1.5 and 4.5 inches from the known target surface (Figure #3 and #4).

Formula: TAN = opposite/adjacent; the ratio to the length of the side *opposite* the angle to the length of the side *adjacent* to the angle. In bloodstain pattern analysis, this formula (Tangent Method) can be applied by measuring the distance from an individual stain to the point of convergence, multiplied by the tangent of the impact angle of the same stain. The resulting figure will provide the distance from the point of convergence to the area in space (three-dimensional) where the source of the blood originated (MacDonell, 1997).

Additional Substrates:

Glass and tile substrates were also subjected to the same experimentation as the drywall and linoleum flooring to observe directionality in comparison to the drywall and linoleum surfaces. Directionality could be established on both surfaces, pointing to an area in the approximate center of the target (area of blood dispersal). Low velocity experiments yielded well defined stains at a known angle. The medium velocity bloodstains on tile and glass in the cold temperature range became diluted and smeared after application. Stains on glass and tile were also observed to run more readily than drywall and linoleum. The smooth surface of glass and tile contribute to this "run effect" (MacDonell, 1997).

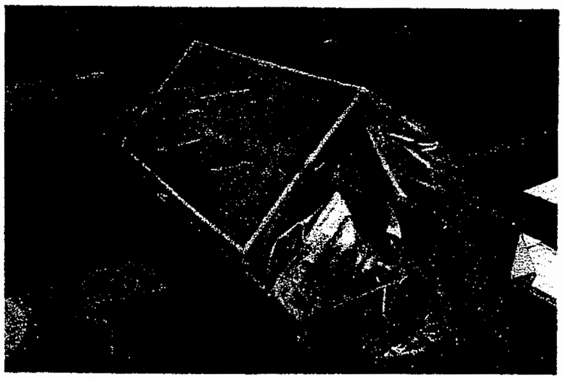
CONCLUSIONS & FINDINGS

Bloodstains created on the drywall and linoleum surfaces in the hot temperatures dried in less time than at the ambient and cold temperatures. This finding may assist investigators attempting to determine the age of bloodstain patterns. In the cold range, the stains appear to freeze upon impact, preserving the appearance of the stain. Although the range of drying times varied throughout the experiment, the overall bloodstain patterns remained consistent throughout the temperature ranges. On the primary surfaces, directionality of bloodstains, known angle, impact angle, and area of origin were reconstructed. The bloodstains and patterns on glass and tile also showed directionality that was consistent with the patterns on the drywall and linoleum. Although temperature may vary the drying times of bloodstains, this project showed that temperature does not adversely affect the overall characteristics of bloodstain patterns.

For future experiments to determine accurate drying times, a check of stains at designated intervals should be employed for all temperatures. Further experimentation in the cold range (high velocity) should be conducted for additional comparison. Further research with bloodstains on cloth in the same temperature ranges has been suggested as a continuance of this project.

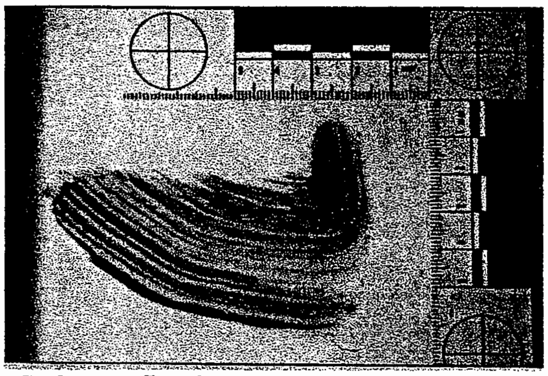
A spreadsheet for the bloodstain measurements and the tangent method calculations are appended as Figures (2) and (3). Various photographs depicting the specially constructed heat chamber, application of blood on substrates in the freezer, and the results of the experiments on drywall, linoleum and tile are appended as Figure (1). Project participants retain the remainder of the numerous photographs taken throughout the experiment.

FIGURE #1

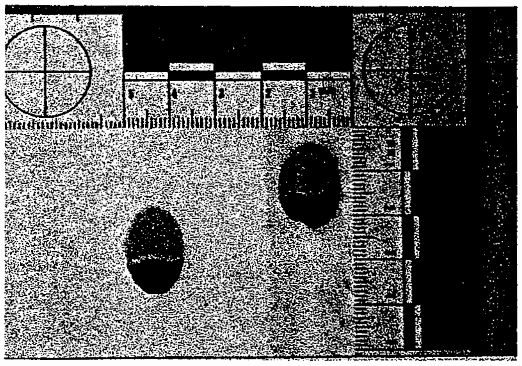


Greenhouse to conduct hot range temperature experiments.

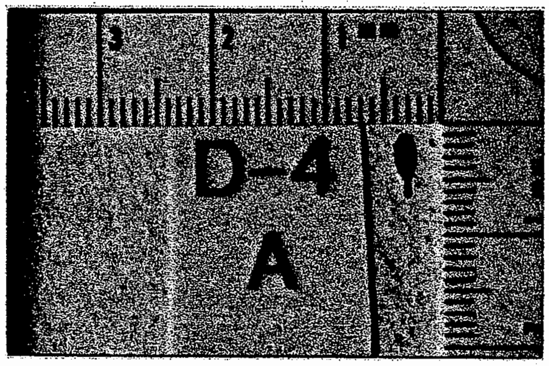
Low velocity on linoleum flooring in extreme cold range.



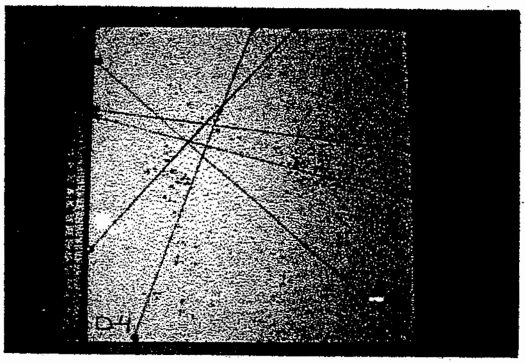
Swipe on flooring moments after removal from freezer.



Drops on flooring moments after removal from freezer.

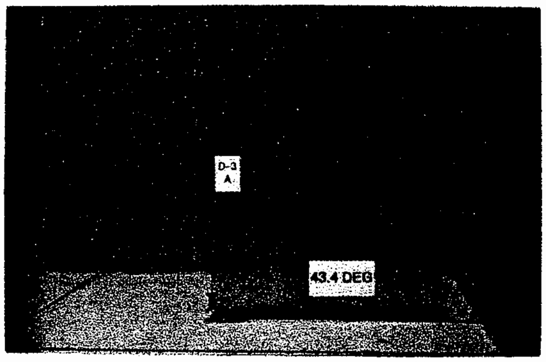


Medium velocity on drywall, Stain A, extreme cold temp. (18 deg. F)

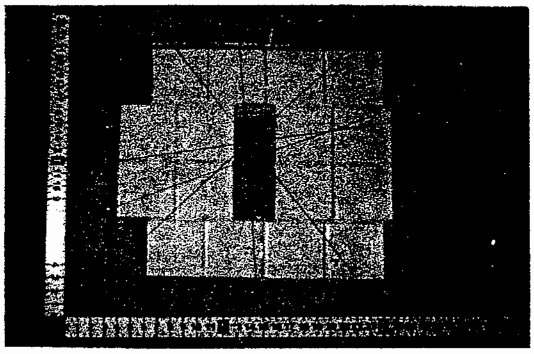


Convergence on drywall (D4), extreme cold range.

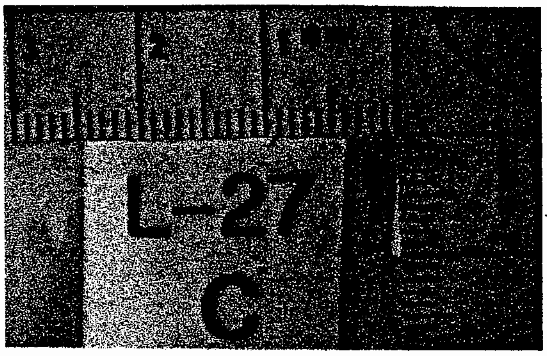
FIGURE #1



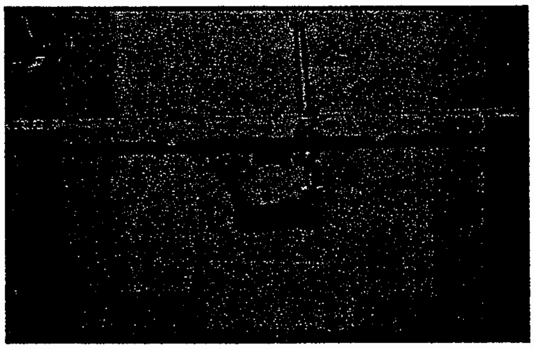
Impact angle measured on drywall in hot temperature range. Actual drop @ 45°



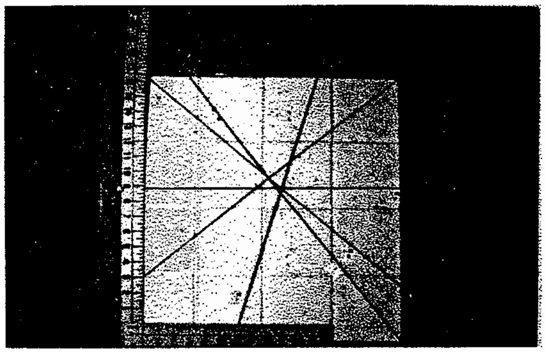
Point of convergence, high velocity tile in high temperature.



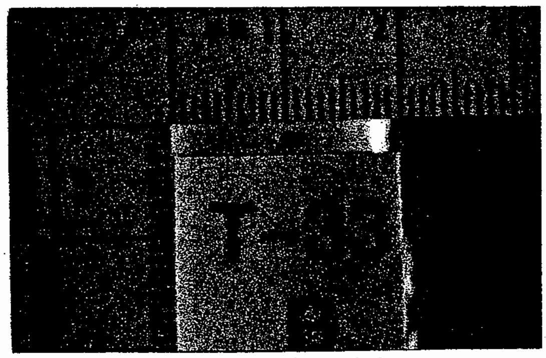
Stain C, high velocity / high temperature 113° on linoleum flooring.



Tile for high velocity experiment in a specially constructed chamber.

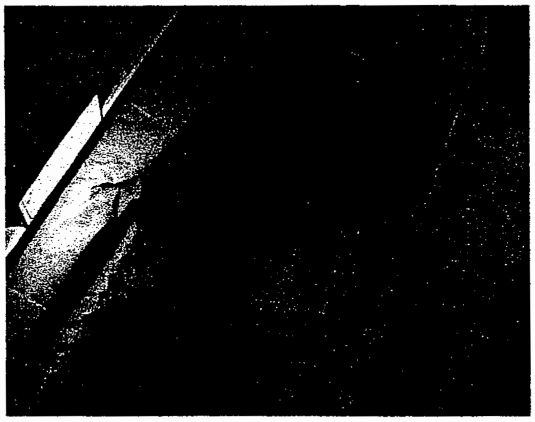


Point of convergence on tile, medium velocity.



Stain B, medium velocity, high temperature range on tile.

FIGURE #1



Tile in freezer prior to low velocity experiment

Moments after low velocity application in freezer

Drywall after medium velocity experiment in freezer

FIGURE #2

Bloodstain Measurements

	A1			A2			AVG	B1			B2			AVG
DRYWALL	**W**	**L**	**Angle**	**W**	**L**	**Angle**		**W**	**L**	**Angle**	**W**	**L**	**Angle**	
D1- COLD	1.2	1.7	44.9	1.3	1.8	46	**45.45**	1.35	2	42.5	1.4	2	44.4	**43.45**
D2- AMBIENT	1.2	1.7	44.9	1.5	1.7	42.6	**43.75**	1.25	1.8	43.9	1.3	1.9	43.2	**43.55**
D3- HOT	1.1	1.6	43.4	1.1	1.6	43.4	**43.4**	1.1	1.6	43.43	1.1	1.6	43.43	**43.43**
D4 - COLD	2	4.6	25.7	2	4	30	**27.85**	1	2	30	1	1.8	33.7	**31.85**
D5- AMBIENT	1.3	1.8	46.27	1.3	1.7	49.8	**48.04**	0.8	2	23.58	1	1.9	31.7	**27.64**
D6- HOT	1	2	30	1.2	2.1	34.8	**32.4**	1	2	30	1	2	30	**30**
D7- COLD	0.8	1.7	28.1	0.8	1.6	30	**29.05**	0.9	2	26.7	0.9	2	26.7	**26.7**
D8- AMBIENT	0.6	1.4	25.4	0.6	1.4	25.4	**25.4**	0.6	1.2	30	0.6	1	36.9	**33.45**
D9- HOT	0.6	1.9	18.4	0.6	1.6	22	**20.2**	1.1	2.2	30	1.2	2.2	33.1	**31.55**
LINOLEUM														
L19- COLD	1.4	2	44.4	1.4	2	44.4	**44.4**	1.4	2	44.4	1.4	2	44.4	**44.4**
L20- AMBIENT	1.4	1.9	47.4	1.3	1.8	46.2	**46.8**	1.4	1.9	47	1.4	1.9	47.4	**47.2**
L21- HOT	1.2	1.8	41.8	1.3	1.8	46.2	**44**	1.2	2	41.8	1.3	1.9	43.1	**42.45**
L22- COLD	1.7	2.8	37.3	1.6	2.6	38	**37.65**	1.8	2.5	46	1.8	2.4	35.7	**40.85**
L23- AMBIENT	1.9	3.5	32.8	1.9	3.5	32.8	**32.8**	1.5	3.4	26.1	1.5	3.3	27	**26.55**
L24- HOT	1.1	2	33.3	1.1	2	33.3	**33.3**	1.2	1.6	48.5	1.2	1.7	44.9	**46.7**
L25- COLD	0.8	1.8	26.4	0.8	1.4	34.8	**30.6**	1	2	30	1	1.8	33.7	**31.85**
L26- AMBIENT	1.6	2.8	34.9	1.8	2.7	41.8	**38.35**	1.2	2	36.8	1.3	2.1	38	**37.4**
L27- HOT	1	3	19.5	1.1	3.2	20	**19.75**	1.3	4.5	16.8	1.3	4.5	16.8	**16.8**

A1/A2 through E1/E2 denote measurements taken by two different examiners of the same stain (A-E).

Stains A and B used for known angles.

Stains A through E used for point of convergence and area of origin.

FIGURE #2

Bloodstain Measurements

	C1			C2			AVG	D1			D2			AVG
DRYWALL	**W**	**L**	**Angle**	**W**	**L**	**Angle**		**W**	**L**	**Angle**	**W**	**L**	**Angle**	
D1- COLD							**0**							**0**
D2- AMBIENT							**0**							**0**
D3- HOT							**0**							**0**
D4 - COLD	1	2.2	27	1	1.8	33.7	**30.35**	1.2	2	32.5	1	2	30	**31.25**
D5- AMBIENT	0.6	1.2	30	0.6	1.2	30	**30**	1.2	2	36.8	1.2	2	36.8	**36.8**
D6- HOT	2.4	4.8	30	2.4	5	28.6	**29.3**	0.6	1.4	25.38	0.8	1.5	32.2	**28.79**
D7- COLD	0.6	1.3	27.5	0.6	1.4	25.4	**26.45**	1	1.8	33.8	1	1.6	33.8	**33.8**
D8- AMBIENT	0.4	0.7	34.8	0.3	0.6	30	**32.4**	0.5	0.9	30	0.4	0.7	34.9	**32.45**
D9- HOT	0.9	2.3	23	0.9	2.4	22	**22.5**	0.3	1	17.5	0.3	1.1	15.8	**16.65**
LINOLEUM														
L19- COLD							**0**							**0**
L20- AMBIENT							**0**							**0**
L21- HOT							**0**							**0**
L22- COLD	1.9	3.3	35.1	1.8	3.8	28.3	**31.7**	1.3	4	18.9	1.2	3.6	19.5	**19.2**
L23- AMBIENT	2	4	30	2	4	30	**30**	1.6	2.6	37.9	1.5	2.5	36.8	**37.35**
L24- HOT	2.9	4	46.4	2.8	4	46.4	**46.4**	1.9	3.9	29.1	1.8	4.4	24.1	**26.6**
L25- COLD	1.5	3.2	27.9	2	2.8	45.6	**36.75**	1.5	3	30	1.4	2.8	30	**30**
L26- AMBIENT	1.3	1.8	46	1.3	1.9	43	**44.5**	1	1.5	42	1	1.5	42	**42**
L27- HOT	1.3	2.6	30	1.5	3.1	28.9	**29.45**	0.8	1.6	30	0.9	1.6	34	**32**

A1/A2 through E1/E2 denote measurements taken by two different examiners of the same stain (A-E).

Stains A and B used for known angles.

Stains A through E used for point of convergence and area of origin.

FIGURE #2

Bloodstain Measurements

	E1			E2			AVG
DRYWALL	**W**	**L**	**Angle**	**W**	**L**	**Angle**	
D1- COLD							0
D2- AMBIENT							0
D3- HOT							0
D4 - COLD	1.1	1.8	37.6	1	1.5	41.8	39.7
D5- AMBIENT	0.6	0.9	41.8	0.6	0.9	41.8	41.8
D6- HOT	0.6	1	36.87	0.7	1.1	39.5	38.19
D7- COLD	0.9	1.7	31.9	0.8	1.4	34.9	33.4
D8- AMBIENT	0.8	1.3	37.9	0.8	1.2	42	39.95
D9- HOT	0.7	1.2	35.7	0.6	1	36.9	36.3
LINOLEUM							
L19- COLD							0
L20- AMBIENT							0
L21- HOT							0
L22- COLD	1.6	2.8	34.8	1.6	2.8	34.9	34.85
L23- AMBIENT	0.7	1.1	39.5	1.6	2.8	34.9	37.2
L24- HOT	1.1	2	33.3	1.1	2	33.4	33.35
L25- COLD	1.7	3	34.5	1.8	2.8	40	37.25
L26- AMBIENT	1.4	2.5	34	1.4	2.4	36	35
L27- HOT	0.6	1.4	25.4	0.7	1.5	27	26.2

A1/A2 through E1/E2 denote measurements taken by two different examiners of the same stain (A-E).

Stains A and B used for known angles.

Stains A through E used for point of convergence and area of origin.

FIGURE #3

TANGENT METHOD

	Angle	Distance of Stain to Point of Convergence(in.)	Tangent (in.)	Average Range of Distance To Target(in.)	Known substrate to target distance(in.)
L22	**COLD**				
A	37.6	11.7	9		
B	40.8	11.5	9.9		
C	31.7	12.5	7.7		
D	19.2	8.2	2.8		
E	34.8	10.2	7.1		
				7.30	**9**
L23	**AMBIENT**				
A	32.8	13.2	8.5		
B	26.5	18	8.9		
C	30	15	8.6		
D	37.3	14	10.6		
E	39.5	7	5.7		
				8.46	**9**
L24	**HOT**				
A	33.3	9.5	6.2		
B	46.7	4.3	4.5		
C	46.4	4.2	4.4		
D	26.6	6	3		
E	33.4	6.5	4.2		
				4.46	**9**
L25	**COLD**				
A	30.6	9.8	5.7		
B	31.9	11.5	7.1		
C	36.5	12.5	9.2		
D	30	10.2	5.8		
E	37.3	8.6	6.5		
				6.86	**8**
L26	**AMBIENT**				
A	38.4	7.7	6.1		
B	37.4	11.7	8.9		
C	44.5	10.7	10.5		
D	42	7.7	6.9		
E	35	12.2	8.5		
				8.18	**9**
L27	**HOT**				
A	19.8	4.5	1.6		
B	16.8	5.2	1.5		
C	29.5	7.2	4		
D	32	7.2	4.4		
E	26.2	6.2	3		
				2.90	**4**

FIGURE #3

TANGENT METHOD

	Angle	Distance of Stain to Point of Convergence(in.)	Tangent (in.)	Average Range of Distance To Target(in.)	Known substrate to target distance(in.)
D4	**COLD**				
A	27.9	11.75	6		
B	31.9	17.6	10.1		
C	30.4	16.6	8.7		
D	31.3	7.6	5.2		
E	39.7	8.7	6.9		
				7.38	**9**
D5	**AMBIENT**				
A	48	9.5	10.5		
B	27.6	11.7	6.1		
C	30	9.7	5.6		
D	36.8	12.2	9.1		
E	41.8	10.1	9		
				8.06	**9**
D6	**HOT**				
A	32.4	8.6	5.4		
B	30	10.7	6.1		
C	29.3	9.5	5.3		
D	28.7	9.2	5		
E	38.1	10.2	7.9		
				5.94	**9**
D7	**COLD**				
A	29	12.5	6.9		
B	26.7	9	4.5		
C	26.4	6.2	3		
D	33.7	8.8	5.8		
E	33.4	10.75	7		
				5.44	**9**
D8	**AMBIENT**				
A	25.3	8	3.7		
B	33.4	11	7.2		
C	32.4	10.5	6.6		
D	32.4	12.5	7.9		
E	39.8	10	8.3		
				6.74	**9**
D9	**HOT**				
A	20.2	4.2	1.5		
B	31.5	6.9	4.2		
C	22.5	7.5	3.1		
D	16.6	4	1.1		
E	36.2	5	3.6		
				2.70	**4**

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