

1989

Determination of the burst initiation location and the tear propagation velocity during air burst testing of latex condoms

Andrew Davidhazy

Follow this and additional works at: <http://scholarworks.rit.edu/article>

Recommended Citation

Davidhazy, Andrew, "Determination of the burst initiation location and the tear propagation velocity during air burst testing of latex condoms" (1989). *Mariposa Foundation Occasional Paper*, no. 13 (). Accessed from <http://scholarworks.rit.edu/article/455>

This Technical Report is brought to you for free and open access by RIT Scholar Works. It has been accepted for inclusion in Articles by an authorized administrator of RIT Scholar Works. For more information, please contact ritscholarworks@rit.edu.

Determination of the Burst Initiation Location and the Tear Propagation Velocity during Air Burst Testing of Latex Condoms

Andrew Davidhazy

Imaging and Photographic Technology Department

School of Photographic Arts and Sciences

Rochester Institute of Technology

One Lomb Memorial Drive, Rochester, NY 14623

ABSTRACT

The stress testing of latex condoms by an air burst procedure has been slow in gaining industry acceptance because questions have been raised regarding the influence of the test apparatus on the likelihood of breakage occurring where the condom is attached to the inflation device. It was desired to locate the areas at which the condoms tend to burst and thus corroborate or disprove these claims. Several factors associated with the bursting condom demanded the use of special instrumentation to detect and study the burst initiation process. Microsecond duration electronic flashes were used for the initial stages of the investigation. Although the absolute point of initiation of a given burst could not be photographed, these high speed studies tend to indicate that the most likely place for high quality condoms to break is not where they are attached to the inflation device but at an intermediate area between the base and the tip of the condom. In addition, tear propagation characteristics and velocities were determined with a delayed-flash technique, a double-slit strip method and a rotating drum framing camera.

2. INTRODUCTION

There is significant interest in the latex condom manufacturing industry to develop a standard and reliable testing method so that industry-wide quality standards may be established. Although there are two quality tests in widespread use today only the air burst test includes the performance of the whole condom in its process. As is suggested by its title, air is pumped into the condom until it bursts. The more stress the latex can withstand the greater the reliability and safety associated with a given product or lot.

The air burst test has been questioned primarily on the influence on the burst initiation process of the device to which the condom is attached. The primary objective of this work was to determine the likelihood that the inflation device would have on the location of burst initiation by simply identifying the burst initiation location for a large sample of condoms.

3. PHOTOGRAPHIC PROBLEMS

Some of the characteristics of the bursting condom that influenced the choice of instrumentation and techniques used for photography include the following:

1) It takes about two to three minutes to inflate an average condom to the point of bursting but the burst can happen at any time within that time period. This means that the camera needs to be ready to record the event for an extended period of time.

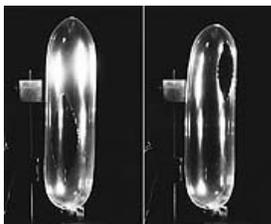
2) The bursting process itself takes place over a very brief time span, often in less than 1/250 second. To resolve sufficient information about the location and progression of the initial burst the camera must operate at high framing rates and at short exposure times.

3) Since the physical size of a fully inflated condom often reaches over 1 meter in length and 50 liters in volume, the latex becomes extremely thin and transparent. This calls for "dark field" type illumination which typically requires more light than standard lighting schemes.

4) These requirements indicate that a high level of local illumination over a large area is needed. The consequence is that the lighting level in itself could influence the bursting process.) Finally, since the camera must be able to detect the onset of the burst at any location along the subject, a camera system with good spatial resolution must be used.

4. HIGH SPEED FLASH PHOTOGRAPHY

The use of short duration flashes negated problems associated with lighting influencing the burst process. Good instantaneous temporal resolution was obtained by photographing with two EG & G 549 microflashes simultaneously fired by connection to a single EG & G triggering unit. The sync signal to the triggering unit was provided by either one of two Dale Beam synchronizers set to operate in the sound activated mode. One of the synchronizers was placed close to the base of the condom and the other was moved upward and held close to the top of the expanding condom. It was assumed that in this manner the flashes would fire with as little delay as a result of the velocity of sound as possible. The cameras were standard 35mm and Polaroid cameras.



The results of this work, completed in cooperation with Roger Stube of Consumers Union and Bruce Voeller of the Mariposa Foundation, strongly indicate that the inflation device does not seem to have a significant effect on the location of burst initiation. Since the photography is initiated as a result of the detection of sound produced by the burst itself, the actual onset of the burst could not be photographed in this fashion. However, reviewing a large number of photographs showing early stages of the burst it became evident that most of the condoms appeared to break preferentially at a point located between the tip and the point of attachment to the inflation device.

Representative photographs obtained in this manner are shown as Figures 1a and b.

In addition, in later work conducted independently by the author, it was observed with reservoir end condoms that, typically as the rip proceeds downwards and upwards, when it reaches the upper and lower areas of curvature the direction of the rip changes from a

vertical direction to a transversal one resulting in the shank region of the condom becoming cleanly separated from the tip and attachment areas. These typically are left intact. That is, the central area of the condom is ripped apart and becomes a flat rubber sheet while the top and bottom regions retain their original shape. This is shown in Figure 2 (not available here).

5. TEAR PROPAGATION VELOCITY MEASUREMENTS

Beyond the test for identifying the location of burst initiation question was raised as to some of the other characteristics of the burst itself. The question that was most often asked had to do with establishing the velocity of the rip at various locations on the condom.

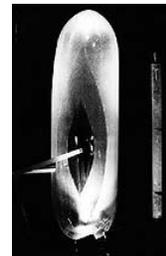
Although this portion of the work was not funded, it was decided to persevere independently to determine the approximate tear propagation velocity along the shank region of fully inflated condoms. A second objective was to use basic to sophisticated techniques that could be used as illustrations to newcomers to the field of high speed photography of several useful approaches to solving a specific high speed problem.

5.1 Velocity measurement by delayed flash technique

To determine the rip velocity in a simple and inexpensive manner, the first system was designed to determine the rip velocity of the tear by basing the measurement on the known velocity of the propagation of sound in air. The lighting apparatus consisted of two standard VIVITAR 283 electronic flashes individually triggered by two Dale Beam synchronizers which were set up so that the sound from the burst would arrive at the second one later than the one located closer to the burst location. Since the distance between them was 150mm, the second flash would fire about 1/2200 second after the first one.

Since the rip was expected to be moving quite fast, short exposure times would be required to secure acceptably sharp images. At 1/32nd power the duration of the flashes was expected to be about/20,000 second according to the manufacturer's specifications.

This was expected to provide reasonable action stopping ability even though the photographs would not be as sharp as those made with the EG&G 549 microflash units. A redeeming factor of the Vivitar units is that they are much more readily available to industrial photographers. Finally, the two EG&G 549's could not be used because the laboratory only has one triggering unit.



The process worked quite well and several images were secured that clearly showed the difference in location of the tearing rubber as a result of the difference in time between the two flash exposures. As a result of these photographs, as illustrated in Figure 3, it was possible to determine that the longitudinal rip velocity of the tear along the shank of a

fully inflated condom is in the order of 465 meters per second and that the transversal velocity of the expanding rip around the perimeter of the shank is in the order of 121 meters/second.

5.2 Double slit strip photography

The second method for arriving at a determination of the rip velocity was based on the use of a small rotating drum streak/strip camera described earlier. Briefly, it is a "home made" camera consisting of a light tight enclosure covering a blower fan onto which the film was attached with sticky tape. The rotation rate of the drum is monitored by a phototachometer. The camera was fitted this time with a double slit assembly. The slits were .5 mm in width and located 1 cm apart. One of the slits included total obstructions to allow the identification of the images at the analysis stage. The drum was made to rotate at 5,000rpm. At this rate it moved the film past the slits at 25,400m/sec. This was the image velocity estimated from the delayed flash technique described above to be approximately the velocity that the image of the tear would be moving at past the slits at the chosen camera magnification of 1:10X.

The double slit strip method is a seldom used technique but for certain situations it appears to be a most appropriate one. It is especially suited to the investigation of the average velocity of subject between two locations in space. The locations of the slits in space can be easily identified either by physical testing or by taking the slit separation within the camera and dividing by the camera magnification.

The velocity of a moving image is found by relating the location and separation between the two recorded images, the separation between the two slits within the camera and the velocity of the film. The principle is that assuming that the two images, recorded at slightly different times are superimposed on each other, then the velocity of the image of the tear is equal to the velocity of the film. The subject velocity is then found by dividing this known velocity by the operating magnification. If, as shown in Figure 4, the two images are not superimposed, then image velocity is determined as follows:

$$V_{\text{image}} = V_{\text{film}} \times D_{\text{slits}} / (D_{\text{slits}} - D_{\text{images}})$$

where V is velocity and D is distance between slits or images, and where the magnitude of D_{images} is + if the image due to the second slit is ahead (in the time direction) than that produced by the first slit, and - if it is behind.

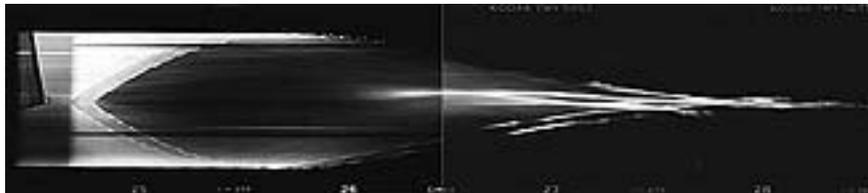


Figure 4. The two offset images of the propagating tear are clearly seen. The one to the right is due to the first slit. The gray area on the left shows the distance between slits. Time base due to strip camera makes event duration measurement easy.

Several tests were run under these conditions and the results agreed with the earlier double flash test, indicating a tear velocity of about 471 meters/second for the longitudinal velocity and 150 meters/second for the transversal velocity in its early stages. The time for the rip to go all the way around the shank was 1/150 sec.

5.3 Dynafax high speed sequence camera

The most sophisticated and expensive method available in our laboratory to determine the tear velocities was to use a Beckman and Whitley Model 351 Dynafax camera. The advantages of the Dynafax to solve the problems associated with the investigation of the bursting condom are manifold. The camera can record at a relatively high framing rate (up to 25,000 16mm full frames/second) thus providing good temporal detail. The exposure time per frames relatively short. With a diamond stop delivering a shutter factor of 1/40 the camera can deliver exposure times of 1 microsecond.

Because the Dynafax is only capable of recording 224 separate frames before double exposing it can not be recording the event under study for an extended period of time. Thus, the shutter or the source of illumination needs to be turned on in anticipation of an event's occurrence and turned off before the drum makes one revolution. In our case, although we looked for a tell tale sign of imminent rupture we could not detect one. Therefore we had to react to the burst initiation as we had for the single flash high speed photographs. That is, the recording would have to start after the sound from the tear process activated one of two sound synchronizers connected in parallel to the input of a high intensity studio electronic flash to which two additional studio flashes were also "slaved". The use of relatively long duration, high light output studio units was required because the light intensity needed to properly expose the film had to be very high because of the short exposure time associated with the framing rate at which the camera was run.

The camera was used at a recording rate of 10,000 frames per second giving an exposure time of 1/200,000 per frame. At this framing rate the drum in the camera makes one revolution in about/50 second. Since the duration of the high intensity flash was in the order of 1/200 second this by itself prevented rewrite or double exposure of the film. In fact, on several occasions two recordings were made on each load of film with success.

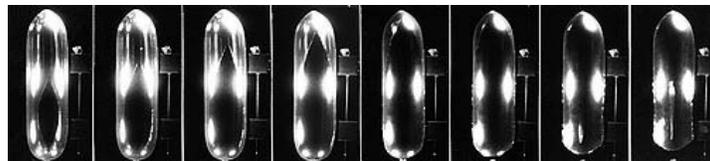


Figure 5. Typical sequence of photographs made at a rate of 5,000ps.

From the sequences thus obtained enlargements were made and data reduced in a straightforward fashion. Since it became apparent that even at 5,000 frames per second

the amount of change between frames was not excessive velocity determinations were made using only one row of images. The results again were in close agreement with those secured with the earlier tests. About 500 meters/second along the shank and 150 meters/second in a transversal direction. representative sequence of frames captured with the Dynafax is shown in Figure 5.

6. CONCLUSION

The location and tear propagation velocity of stretched latex condoms was investigated with several instruments and techniques associated with applied photoinstrumentation. They all appeared to corroborate each other as far as the location of burst initiation and the order of magnitude of tear propagation velocity. Single flash photographs and Dynafax sequences although not capable of recording the earliest manifestation of a tear or burst do suggest that the majority of the bursts seem to start at a location between the upper and lower curved sections of the inflated condom. It appears to this author that this area is, in fact, the one which is subjected to the greatest stress and that the region of attachment and the tip are, in fact possibly the least stressed regions of the fully inflated condom. More extensive testing would be necessary to assign statistical significance to these observations.

In addition, tear propagation velocities along the two areas where the shank either curves towards the attachment device and the area at the top where it curves towards the tip are two regions where the transversal rip velocity seems to be equal to or even greater than the longitudinal tear velocity. More detailed analysis of these regions is in progress.

7. ACKNOWLEDGEMENTS

The initial stages of this work were supported by a grant from the Science and Materials Division of the Food and Drug Administration. would like to thank my collaborators in that effort, Mr. Roger Stube of Consumers Union, Mt. Vernon, NY and Mr. Bruce Voeller of the Mariposa Foundation, Toppanga, CA.

The author also wishes to thank the School of Photographic Arts and Sciences of the College of Graphic Arts and Photography at the Rochester Institute of Technology for putting at his disposal laboratory space and providing the opportunity to complete this research.

The author is grateful to the Safetex Corporation, Lyndhurst, NJ for providing condoms for this research free of cost.

8. REFERENCES

1. R. Stube, B. Voeller, A. Davidhazy, "High Speed Cinematography of the Initial Break-point of Latex Condoms during the Air Burst test," *Contraception*, Vol. 41, No. 6, pp. 591-603, June 1990.

2. A. Davidhazy, "Simplified Streak/Strip and Scanning Photographic Systems", Proceedings of the 15th International Congress on High Speed Photography and Photonics, Lincoln Endelman, Editor, Vol.348, pp. 148-153, SPIE, 1985.

3. A. Davidhazy, "Applications of Fast and Slow Streak Recording cameras", Proceedings of High Speed Photography, Videography and Photonics V, Howard Johnson, Editor, Vol. 832, pp.117-121, SPIE,987.

I've run across some reference material that may be useful in the future:

A. Castenholz, Dept. of Human Biology, University of Kassel, Germany wrote several articles on "stripe photography". One entitled MICROKYMOGRAPHY AND RELATED TECHNIQUES is especially interesting.

He also mentions a patent issued to F. SONNE in 1940 on aerial strip cameras. It is US Patent 2307649.

John C. Beckman, "A temporal sequence camera system", Photographic Science and Technique, a quarterly supplement to the Photo Society of America Journal, Section B, February 1951, pp 24-26.