Shelf life
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The Problem

• Condoms deteriorate as they age
• Experience shows that condoms can deteriorate very quickly in hot climates
What we don’t yet know

• What are the chemical reactions that govern the aging of rubber in condoms?

• Note work by Dr Potter, showing cross-link changes

• What is the relationship between the progress of the reactions and change of physical properties?

• Does compliance/non compliance with the standard after some years indicate good/bad quality? (We do know a little about this, but not enough)
The Most Important Tests

Holes:
  Two alternative methods, visual and electric
  Count the number of holes
  Limited in principle to 0.25%
  (We believe that the number of holes does not change with age, but there are suggestions to the contrary)

Inflation:
  Measure burst volume and pressure
  Count number below limit
  Limited in principle to 1.5%
  (We know inflation properties do change with age)

Package Seal:
  (we know that leakage of lubricant makes a mess)
What is shelf life?

1. The period during which the condom can be expected to perform satisfactorily, OR

2. The period during which the condom meets all the requirements of ISO 4074?

ISO 4074 uses the second definition
Current shelf life requirements

• Pass inflation test after 90 days at 50°C
• Demonstrate shelf life by real time study at 30°C, using inflation test
• Until real time data is available, you can use accelerated tests to give provisional results
• (Pass inflation test after 7 days at 70°C)
Previous situation

• The standards were ambiguous about the meaning of shelf life
• Even when a manufacturer was required to indicate expiry date on the pack, the meaning was not defined
• It was not made clear whether standards were expected to apply until the expiry date, or only when the condoms were new, or for the first 12 months
• Some standards explicitly said that oven aging did not apply to products over 12 months old.
Current situation

- In 1997, the USFDA introduced requirements for a type test after aging at 40 to 50°C for 90 days, and a real time test requirement at 15 to 30°C.
- ISO 4074:2002 explicitly stated that the condoms must meet the inflation requirements until the expiry date, and requires a real time test at 30°C.
- The 2003 WHO Specifications called up the technical requirements of ISO 4074.
- In the 2015 standard the condoms must meet the inflation, holes and pack integrity requirements until the expiry date, and requires a real time test at 30°C.
History of Shelf Life Control

• In the 1980s PATH demonstrated that condoms with very low burst volumes were likely to break in use

• Up to the mid 1990s, ASTM and WHO required only the manufacturing date (shelf life was assumed by WHO to be site-dependent)

• Oven conditioning for as little as 2 days at 70°C was assumed to be an assurance that the condoms would last 5 years.

• Some standards required an expiry date, but did not define it
History of Shelf Life Control - II

- In the 1980s, in response to obvious problems with product quality, PATH introduced the CDI, then the CQI, to measure the quality of condoms in the distribution chain.
- Inflation and leaks requirements on new condoms were gradually tightened.
- WHO required Al foil packs and a package seal test.
- In the 1990s, PATH undertook a major study of condom deterioration.
- At the same time, ISO and WHO began requiring an expiry date on packs.
History of Shelf Life Control - III

- FHI conducted a breakage trial of condoms of different age and burst volume, finding that condoms with lower burst volume broke more often.
- In 2002, ISO 4074 included real time and accelerated aging requirements to prove claimed shelf lives (limited to 5 years), and based mainly on inflation testing performance.
Basis of Shelf Life Model

• Physical parameters (originally burst volume and pressure) are used as the sentinel variables for deterioration

• The cause of deterioration is assumed to be a chemical reaction, which can be monitored by the burst properties

• Freedom from holes and pack seal were added in the 2014 requirements of ISO 4074, as a result of reports from the distribution chain
Clinical Basis for Using Volume

• In 1980 to 1986, PATH did trials in Indonesia that showed condoms with (very) low burst volumes tended to break in use – also that UV exposure causes burst volumes to fall.
Clinical basis for using volume

• In 1991, FHI measured breakage rates as a function of inflation and tensile properties
• CQI and mean burst volume were inversely correlated with breakage in use
• Also, old condoms broke more often than new ones (but older condoms had lower burst volumes)
Breakage vs % Vol Rejects

\[ \text{condom breakage rate} = 5.80 + 0.59(\% \text{ reject}) \quad R^2 = 0.70 \]
Breakage vs Mean Volume

condom breakage rate = 20.11 - 0.44(air burst volume)  \( R^2 = 0.43 \)
What happens to condoms as they age at room temperature?

- For most condoms, the volume goes down
- For most condoms, the pressure does not change much (may go up or down)
- For some condoms the pressure goes down
- For very few condoms, the volume remains almost constant
A “Good” Volume Histogram

Volume (L)

Number

Pass/fail

Limit

Mean = 35.68
Slight decay……
More decay……
ISO 4074 (and UNFPA) requirements

• Minimum stability requirements – condoms must meet inflation requirements after 7 days at 70°C, and after 90 days at 50°C.

• Real time stability study – must meet holes, inflation and package seal requirements after the stated shelf life at 30°C.

• Note that an accelerated study is only acceptable as an interim measure – until the real time one is finished.
Conducting a real time study

- ISO 4074 requires a real time study on 3 batches
- The study should be repeated if there is a significant change to the formulation or process
- The study needs to be done at 30°C
- Different lubricants or pigments (or even shapes) may change the shelf life
Conducting a real time study

For each condom design, you need:

• A room held at 30°C (actually 28°C to 35°C) for the entire study (temperature should be monitored and recorded)

• Define the date of manufacture (dipping or foiling) – see later

• Decide maximum shelf life you want

• 3 batches of condoms meeting dimensions, inflation, holes, visible defects and pack integrity requirements of ISO 4074
Conducting a real time study

- Set aside enough condoms to do all the tests, plus spares.
- Test a relatively small number of condoms (32 to 50) at selected intervals (1 year or less) from each lot to determine the trend of burst properties over time.
- When it looks as if the product may be reaching its limit (or you reach your desired shelf life), then do a full ISO 4074 test to verify that it still passes. Include a holes test.
- You should have enough samples to do the full final test twice, in case you want to extend by one time interval.
Determining the end-point

- ISO 4074 currently has a maximum shelf-life of 5 years
- Towards the end of the shelf life, test every 6 months
- Calculate expected number of non-compliers from the mean and SD (1.5% of the distribution can be below the limit). Mean-Limit>2.17*SD. One lot can fail one test on this basis.
- Build in a safety margin – don’t push the shelf life to the limit where the product would really fail
- Stop and do the next step if the product looks like failing
- At the end of the shelf life, you must test for inflation, holes and pack seal, using Annex A sampling plans
The starting point

• The date of manufacture can be the dipping date or the foiling date.
• The date of manufacture must be < 2 years after the date of dipping
• The shelf life assessment must use condoms that have been stored for the maximum allowable time between dipping and foiling
Accelerated Ageing Studies

• These are to determine provisional shelf life claims, until the real time study is completed

• There are 2 options available:
  – No control product with real time data available
  – Control product with real time data available

The control product must also have accelerated data available, which are suitable for verifying the shelf life
No control product available

• Choose 3 lots that comply with inflation, holes, visible defects and pack seal requirements.
• Choose enough samples to test according to Annex A
• Condition the samples in an oven at 50°C. At the end of the stipulated period, test the condoms for inflation, holes and pack seal
No Control Product Available

• The provisional shelf life that can be claimed depends on the oven conditioning time, as follows:
  – 90 days allows 2 years
  – 120 days allows 3 years
  – 180 days allows 5 years,
Provided the condoms pass the tests.
It may be wise to run more than 1 test in parallel, so that, eg, 3 years can be claimed if the products fail after 5 years.
Control Product Available

• The control product must have real time data available
• Condition 2 production lots of control condoms and 3 lots of test condoms at selected temperatures (at least 2 different temperatures recommended), to establish the time-temperature curves.
• Compare the behaviour of the two products, & establish suitable ageing conditions for the test product
• Use these conditions to do a test using samples according to Annex A for inflation holes & pack seal.
• All lots must pass the tests.
Repeating the study

• The shelf life study needs to be repeated if there is any “significant” change to the formulation or processing conditions.
• This is not rigorously defined.
• Eg - complete change of a component chemical would need a repeat, but a change of supplier would not.
• A substantial change to the per/post vulcanisation balance would need a repeat.
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value
choice

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