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MAGNETS: SOME PHYSICS EVERY CONSERVATOR NEEDS TO KNOW

Résumé

La compression est un problème important lors du traitement des artefacts en papier, mais elle est de moindre importance avec le cuir ou le parchemin. La cellulose a une résilience relativement faible, la capacité de retrouver la forme; les peaux d'animaux sont le contraire. Ces propriétés sont liées au degré de partage d'électrons entre les matériaux, qui détermine leur placement relatif sur la série triboélectrique. Certaines combinaisons de matériaux ont de meilleurs pouvoirs de détention que d'autres. Le matériel choisi pour être en contact avec un artefact pourrait-il également contribuer à la préservation d'un artefact ou à son soutien? La philosophie de longue date parmi les restaurateurs de «comme avec comme» peut-être besoin d'être réexaminé.

Keywords: Compression of paper, magnetic mounting systems, resiliency of leather, Tribo-electric series

Compression

Compressive strength is the capacity of a material or a structure to withstand perpendicular forces against its surface. When the limits of compressive strength are reached, a material is crushed. Museum professionals have long held that this risk of damage from compression is a significant disadvantage of using magnets. What materials can sustain compression? What is the effect of the age or structure of the material on compressive strength?

Compressive strength is usually reported in relation to specific technical and industry standards that have slowly evolved. However, many museum professionals are hindered by the fact that many artefacts have not been tested against technical standards. Changes that occur as materials age also reduce artefacts' compressive strength. Artefacts are not merely raw materials, but rather materials that have been manipulated and manufactured into an end product, and then further altered by cultural use and wear.

A specific material's thickness, its method of manufacture, any added coatings, and its loft all help determine a material's potential to become compressed. The material's method of manufacture and structure also helps determine its physical response to compression; for leather, the fibrous structure has been subjected to many methods of processing over the years to maintain its viability as a material. For paper, fibres are pounded and made into a slurry before being formed into a sheet and then finished with coatings and fillers. Newer materials withstand longer-term compression better than older materials do. Another factor that influences compressive strength is how long a material has been under constraint.[1] Surface deformation has been known to occur for works of art on paper that have been matted for an extended time;[2] this same phenomenon can occur in magnetic systems, wherein gap materials become burnished. An artefact's history of use, as well as how it was manufactured, can play a role in how compressed it is. For example, well-used moccasins will have soles with more fully compressed leather fibres.

Resiliency

Resilience describes a fibre's ability to return to its original shape. It is the ratio of the energy of retraction to the energy of deformation and is influenced by temperature, moisture content, rate of strain, retraction, and strain history.[3] Various materials are rated on a scale of resiliency (Table 1). [4] Materials that show good tensile recovery also tend to have high compression recovery.[5] Cellulosics as a group have low resiliency, as is evidenced by plate marks on prints. This may partially explain why paper conservators often see compression as a result of using mounts with magnets on the surface of the work of art. Of course, an artefact's previous use—either historically or while in a museum—will affect the extent of its compression. An example is bark cloth, also a type of cellulose, that is thoroughly "beaten" during its manufacturing.[6] Polyester materials, in contrast, are on the opposite end of the resiliency scale; having very high resiliency, with protein-based materials immediately below.

Table 1: General resiliency ranking by material

Material	Resiliency
Polyester	High
Wool / proteins	↑
Nylon	
Acrylic	
Olefin (PE, PP)	
Triacetate	
Silk	
Acetate (secondary)	
Cotton	
Rayon	↓
Flax	Low or poor

Another quality to consider when choosing a material in contact is "loft", which is the amount of curvature to which an artefact is required to respond. Conservators often prepare a soft surface for a leather artefact to rest on; while works of art on paper are on hard surfaces. Figure 1 illustrates padding being placed below an artefact and below the magnet. It is possible for a padded layer to prevent the compression of an artefact. Selecting the right materials and placing them in well-considered locations in the magnetic system can reduce compression, especially with magnetic point fastener systems. For instance, one can select a padding material softer than the artefact to reduce compression. The artefact will then have at least one direction it can move in; if it is surrounded by two hard surfaces, it will have nowhere to move and will become compressed.

1 A. de Graaf, 'Tensile Propoerties and Flexibility of Textiles', in: *Conservazione e Resauro dei Tessili*, ed. by F. Pertegato (Milano: CISST, 1980), 54-61.

2 J. Vuori, R. Dancause, and S. Michalski, 'Renewing the Past: Pressure Mounting Two Large Fragmented Flags', in: *Textile Specialty Group Postprints*, 23 (2013), 161-80.

3 Dillon, 'Resilience of Fibers and Fabrics', in: *Textile Research Journal*, 17:4 (1947), 207-13.

4 M. Ballard, 'Mechanical Properties: Preview and Review', in: *Textile Conservation Newsletter*, 28 (1995), 4-28.

5 W. Morton and J. Hearle, *Physical Properties of Textile Fibers* (London: Butterworths, 1962).

6 G. Spicer, 'Mounting Barkcloth with Rare Earth Magnets: the Compression and Fiber Resiliency Answer', in: *Recent Advances in Barkcloth Conservation & Technical Analysis Postprints*, <Kew Gardens, UK, 7 December 2018>.

Fig. 1: Compression and loft, schematic illustration; a) An artefact being compressed within the magnetic system, b) An artefact conforming to the magnet on a padded surface, c) An artefact with cushioning below the magnet

Adding a thin, soft surface to the underside of a magnet provides additional support to the artefact by absorbing compression (Fig. 1). Paper or photographic artefacts need to rest on a denser material. In a magnetic system, placing the padding material below the magnet is a possible solution, as depicted in Figure 1c.

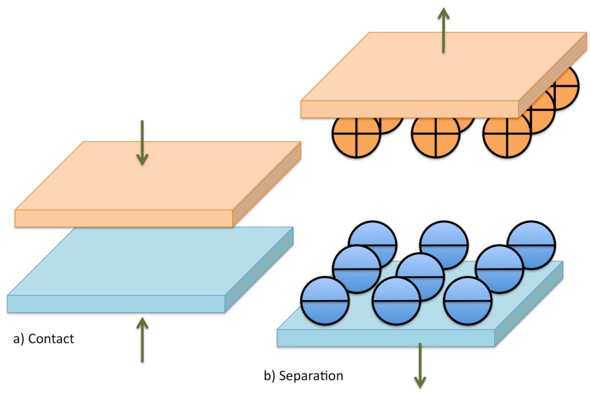

Fig. 2: Schematic of electron exchange when two different materials are in contact and are then separated

Static Charge and the Triboelectric series

All matter is composed equally of both positive and negative charges.[7] The basis of electrostatic charging is a surface phenomenon in which the disruption of the condition of equilibrium is seen in the neutral atom.[8] The static charge occurs when materials initially in contact are separated without any apparent rubbing or when materials are rubbed together. More static is created with rubbing than with simple contact and separation.[9] [10] When materials are in contact, electrical charges develop—which is something that a conservator usually seeks to avoid when working with collections.[11] Electrical charges occur when bonds between electrons, which are established when materials come into contact, are then broken upon separation (Fig. 2).[12] [13] [14] [15] [16]

Materials that can gain or lose electrons are called triboelectric materials. The order of the propensity to gain or lose electrons is called the triboelectric series.[17] The series is based on the conductivity of the individual material. The level of charge is linked to a material's placement in this series (Table 2). It is the distance of the two materials from one another on the series that

7 S. Sello and C. Stevens, 'Antistatic Treatment', in: *Handbook of Fiber Science and Technology*, vol. II: *Chemical Processing of Fibers and Fabrics, Functional Finishes, Part B*, ed. by M. Lewin and S. Sello, (New York: Marcel Dekker, Inc., 1984), 291-313.

8 L. Commoner, 'Static Electricity in Conservation', in: *ICOM Ethnographic Conservation Newsletter*, 18 (1998).

9 A. Blythe, 'Anti-Static Treatment of 'Perspex' for Use in Picture Frames', in: *Studies in Conservation*, 19:2 (1974), 102–4.

10 Sello and Stevens, note 7, 291-313.

11 L. Gercia-Vedrenne and K. Thompson, 'Working With and Against Static Charges', <New England, American Institute for N NOTEConservation 47th Annual Meeting, 13-17 May 2019>.

12 R. Carleton, *Vitalized Physics* (New York : College Entrance Book Company, Inc., 1962).

13 R. Allen, Triboelectric Generation: Getting Charged (Chino: Desco Industries Inc., 2000).

14 M. Ballard, A. Gentry, and N. Dalela, 'The Triboelectric Series with Silk & Plexiglas Pressure Mounts', in: Tip Session <Houston, TX, American Institute for Conservation 46th Annual Meeting, 31 May – 2 June 2018>.

15 G. Ioanid, D. Parpauta, and A. Vlad, 'The Electrostatic Behaviour of Materials Used in Restoration-Conservation Process', in: *Journal of Optoelectronics and Advanced Materials*, 7 (2005), 1643–49.

16 M. Suh, A. Seyam, W. Oxenham, and T. Theyson, 'Static Generation and Dissipation of Polyester Continuous Filament Yarn', in: *The Journal of the Textile Institute*, 101:3 (2010), 261–69.

17 Sello and Stevens, note 7, 291-313.

Table 2: Material Order of the Triboelectric Series

Charge	Material	Notes
+ + +	Air	
	Polyurethane foam	
	Hair	
	Nylon, Dry skin	Dry skin has the greatest tendency to give up electrons and becoming highly positive in charge.
	Glass	This is why TV screens collect dust on their surfaces.
	Acrylic, Lucite	This is why these materials are not used to frame pastels.
	Leather	
	Rabbit's fur	Fur is often used to create static electricity.
	Quartz	
	Mica	
	Lead	Surprisingly close to cat fur.
	Cat's fur	
	Silk	
	Aluminum	
	Paper	
	Cotton	Best for non-static clothes
	Wool	
NEUTRAL		
	Steel	Not useful for static electricity
	Wood	Attracts some electrons, but is almost neutral
	Amber	
	Sealing wax	
	Polystyrene	
	Rubber balloon	
	Resins	
	Hard rubber	
	Nickel, Copper	
	Sulfur	
	Brass, Silver	
	Gold, Platinum	
	Acetate, Rayon	
	Synthetic rubber	
	Polyester	
	Styrene and Polystyrene	Why packing peanuts seems to stick to everything.
	Plastic wrap	A.k.a. "Cling" wrap
	Polyethylene	
	Polypropylene	
	Vinyl, PVC	
	Silicon	
	Teflon	Teflon has the greatest tendency of gathering electrons on its surface and becoming highly negative in charge.
	Silicone rubber	
- - -	Ebonite	

Table 3. Material types commonly found in artefacts, their position on the series and suggested display material content

Material type of the Artifact		Material's position on the Series	Suggested Material types for Display
Cotton	Cellulose	Immediately above neutral	Polyester, Rayon (further down the series)
Leather	Protein	Well above neutral	Cotton, rayon, polyester (further down the series)
Nylon	Synthetic	Above leather	Cotton, rayon, polyester (further down the series)
Rayon / Acetate	Synthetic	Well below	Cotton, Silk (further up the series)
Polyester	Synthetic	Below rayon	Cotton (further up the series)

increases the charge effect rather than the specific location in the series. Therefore, if two materials in contact are neighbours on the scale, there is less exchange. However, exchange occurs if they are far apart, no matter where on the scale.

Mounting material section using the series

Could the use of the series and its adhesion capabilities be part of the consideration in selecting the material type for the mounting of an artefact? It is possible that the selection provides added support in conjunction with adhesive or other methods of attachment. The amount of distance and its associated benefit is not fully known or understood.[18]

When a display material is selected, its composition should be located some distance on the series for the artefact's composition. For many cases, this would introduce more synthetic materials and blends that are not typically standard (Table 3). Most studies focus on the reduction of this naturally occurring phenomenon, but conservators could embrace it. The addition of polyester with cotton does contribute to increasing electron exchange.[19] [20] In fact, the higher the percentage of polyester, the more sharing occurs.

Conclusion

The investigation of magnetic mounting systems leads to several findings regarding material behaviour.[21] First, cellulosic fibres are made of low-resiliency-rated materials. Introducing the concepts of the triboelectric series and resiliency has the potential to help explain why compression occurs in some materials and not others. Are there potential methods for limiting this effect?

The unique ways that polyester, nylon, and other synthetics impact magnetic systems can only be explained by considering surface characteristics, frictional forces, electrical changes and resiliency. For instance, the reason paper is "noticeably" compressed is because of its low resistance characteristics. Understanding these phenomena always involves calling on a mixture of physics and textile science. However, more research is needed to fully understand all of the forces that are present when materials come into contact with each other.

18 G. Spicer, 'The Principles of Creating a Magnetic Mounting System: The Physics Every Conservator Needs to Know', in: *ICON Textile Group 2017, From Boxes to Buildings: Creative Solutions for the Storage of Textiles and Dress*, ed. by S. Glenn ACR and K. Smith (Bath, UK : ICON, 2017), 59–75. G. Spicer, 'Why do Polyester Fibers Attach so Well to Wool?', in: *Inside the Conservator's Studio: An Art Conservator's Journal*, created: November 1, 2017, available from: https://insidetheconservatorsstudio.blogspot.com/2017/11/why-do-polyester-fibers-attach-so-well.html (accessed 14 August 2019). G. Spicer, 'The Triboelectric Series: An Introduction', in: *Annual Textile Specialty Group Tip Session* <Houston, TX, American Institute for Conservation 46th Annual Meeting, 31 May – 2 June 2018>.

19 K. Shoush, M. Mohamed, H. Zaini, and W. Y. Ali, 'Measurement of Static Electricity Generated from Contact and Separation of Clothes and Car Seat Covers', in: *International Journal of Scientific & Engineering Research*, 4:10 (2013), 33-8.

20 M. Mahmound and A. Ibrahim, 'Friction Coefficient and Triboelectrification of Textiles', in: *Journal of Multidisciplinary Engineering Science and Technology*, 3:2 (2016), 3970-6.

21 G. Spicer, *Magnetic Mounting Systems for Museums and Cultural Institutions* (Delmar: Spicer Art Books, 2019).

Conservators routinely regard static as an unavoidable difficulty.[22] From the above discussion, the exchange of electrons and the build-up of static charge could also be beneficial, aiding in support.

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22 C. Jenkins, 'Survey, Static Electricity in Conservation', in: *ConservationDistList*, distributed April 10, 2018. Available from: https://docs.google.com/forms/d/e/1FAIpQLSe972ZMp7P-qRN33Dq7jWQQx-ogXjCUKYBEAQWIekWhCzAYmsA/formResponse (accessed 12 January 2019).