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TECHNICAL NOTE

STANDARDIZING THE REPORTING OF ABRASIVE PAPERS USED TO SURFACE TREE-RING SAMPLES

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ABSTRACT

Dendrochronologists traditionally report the grit size on abrasive papers used to prepare surfaces for tree-ring analysis, but significant differences exist in the measured particle size ranges defined by the different systems (*e.g.* FEPA, ANSI, ISO, JIS, *etc.*) used worldwide. The systems themselves are also subject to change and discontinuation. We propose that dendrochronologists report (1) the standard used to manufacture the grit (*e.g.* ANSI in the U.S.), (2) the grade within the standard (*e.g.* 400-grit), and (3) the SI equivalent measurements of mean or included-range grit-size dimensions (*e.g.* 20.6–23.6 μm). For example, rather than reporting our use of 60-grit or 400-grit, we would instead report ANSI 60-grit (250–297 μm) and ANSI 400-grit (20.6–23.6 μm) sandpaper. Adopting SI equivalents will help standardize our methods by providing concise, replicable information about surface preparation, considered by many the most crucial step for helping to define clear ring boundaries and to ensure successful crossdating.

Keywords: Abrasive paper, sanding methods, SI standard.

INTRODUCTION

Although selection of abrasives seems fairly straightforward to most dendrochronologists, this may not always be the case. Suppose, for example, that an American is collaborating with Japanese colleagues on comparing the ring-forming characteristics of the Asian and North American species of a particular genus of tree. At some point in their association one of the Japanese colleagues comments that they are puzzled by the methods reported in the American's papers. His methods involve finishing sections with 400-grit sandpaper, but when the Japanese colleagues reach 400-grit the surface is still unacceptable. On the other hand, the sections sent to them by the American have excellent surfaces. The discrepancy is resolved when further investigation reveals that 400-grit paper in Japan is considerably coarser than 400-grit paper in the U.S.!

Dendrochronologists sand or otherwise surface their samples until they can clearly view microanatomical features such as cell walls. Deciding when one has reached that point is inherently subjective, however, so preparation methods reported in the literature typically refer to the grade of sandpaper used to achieve the final surface. As a means of communicating one's methods this is a very reasonable practice, because normal methods of measuring the smoothness of the surface itself do not work for a microporous material like sectioned wood. For example, engineers and manufacturers specify polished metal finishes and other finishes in surface metrology not by the size of grit used to achieve a finish, but by the smoothness of the resulting surface (*e.g.* R_a or "roughness average," the integral of the absolute values of the roughness profile across the surface in relation to the mean). Because the roughness profile of sectioned wood includes the interior spaces of the cells and vessels that the investigator plans to examine, measurements like R_a have little practical meaning. Reporting the grit size makes practical sense (see "Grit versus Finish," below).

Table 1. Effective size ranges in micrometers for abrasive grit sizes in several current systems. The way standards are defined varies between systems and by analytic technique. These numbers are sufficient for reporting in dendrochronology.

International		U.S.A.		Europe*		Japan		China	
ISO(86)	μm	ANSI(74)	μm	FEPA(93)	μm (mean)	JIS(87)	μm	GB2478(96)	μm
P22	850–1000			P20	1000			22	850–1000
P24	710–850	24	707–841	P24	764	24	710–850	24	710–850
P30	600–710	30	595–707	P30	642	30	600–710	30	600–710
P36	500–600	36	500–595	P36	538	36	500–600	36	
P40	425–500			P40	425			40	425–500
P46	355–425	46	354–420			46	355–425	46	355–425
P54	300–355	54	297–394	P50	336	54	300–355	54	300–355
P60	250–300	60	250–297	P60	269	60	250–300	60	250–300
P70	212–250	70	210–250			70	212–250	70	212–250
P80	180–212	80	177–210	P80	201	80	180–212	80	180–212
P90	150–180	90	149–177			90	150–180	90	150–180
P100	125–150	100	125–149	P100	162	100	125–150	100	125–150
P120	106–125	120	105–125	P120	125	120	106–125	120	106–125
P150	75–106	150	74–105	P150	100	150	75–106	150	75–106
P180	63–90	180	63–88	P180	82	180	63–90	180	63–90
P220	53–75	220	53–74	P220	68	220	53–75	220	53–75
ISO(77)	μm	ANSI(77)	μm	FEPA(93)	μm	JIS(83)	μm	GB2477(83)	μm
P240	56.5–60.5			P240	56.5–60.5	240	56.0–64.0	W63	50.0–63.0
P280	50.2–54.2	240	50.0–53.5	P280	50.2–54.2	280	49.0–55.0		
P320	44.7–47.7			P320	44.7–47.7	320	43.5–48.5	W50	40.0–50.0
P360	39.0–42.0	280	40.5–44.0	P360	39.0–42.0	360	38.0–42.0		
P400	33.5–36.5	320	32.5–36.0	P400	33.5–36.5	400	32.0–36.0	W40	28.0–40.0
P500	28.7–31.7			P500	28.7–31.7	500	26.0–30.0	W28	20.0–28.0
P600	24.8–26.8	360	25.8–28.8	P600	24.8–26.8	600	22.5–25.5		
P800	20.8–22.8	400	20.6–23.6	P800	20.8–22.8	700	19.7–22.3		
P1000	17.3–19.3	500	16.7–19.7	P1000	17.3–19.3	800	17.0–19.0	W20	14.0–20.0
P1200	14.3–16.3	600	13.0–16.0	P1200	14.3–16.3	1000	14.5–16.5		
P1500	9.5–11.1			P1500	11.6–13.6	1200	12.0–14.0	W14	10.0–14.0
P2000	8.5–10.5	800	9.8–12.3	P2000	9.5–11.1	1500	9.5–11.5		
P2500	7.9–9.1	1000	6.8–9.3	P2500	7.9–8.9	2000	7.8–9.2	W10	7.0–10.0
		1200	4.5–6.5			2500	6.3–7.7		
						3000	5.2–6.2	W7	5.0–7.0
								W5	3.5–5.0

*The respective standards associations of India, the Russian Federation, the Union of South Africa, and Turkey are also corresponding members of FEPA.

Doing so, however, is only useful if your grit size numbers are meaningful to others. As the USA-Japan example illustrates, such meaning may be elusive. In fact, "400-grit" in the U.S. is about the same as "800-grit" in Europe, whereas in Japan you would use "600-grit" to achieve the same finish (Table 1). Grit designations also change over time. In the U.S., sanding papers were once graded with numbers like "00" and "000" in the finishing grades, or solely with verbal descriptions such as "very fine" and "extra fine" (Table 2). A single international standard may be adopted in the future (*e.g.* ISO 86, Table 1), but for that to happen many of today's standards will necessarily be replaced and their meanings will fade from memory.

We have three primary goals in writing this report. First, we wish to make the dendrochronological community more aware of the differences in abrasive paper grading systems. Second, we wish to provide the information researchers need to *un-*

Table 2. Approximate equivalents for customary U.S. terms (accepted usage in the industry, not vernacular usage) and historic sandpaper grades. Historic grades were less standardized than today's. Grades such as 2/0 and 3/0 are also written 00, 000 or may be spelled out as two-aught, three-aught.

Term	One or More Grades Within the Range (μm)	Pre-CAMI U.S. Grade	Typical Mean Size (μm)
Extra Coarse	1000–2000	3	715
Very Coarse	500–1000	2	535
Coarse	250–500	1	351
Medium	125–250	0	192
Fine	63–125	2/0	141
Very Fine	40–63	3/0	116
Extra Fine	25–40	4/0	93
Super Fine	10–25	5/0	78
		6/0	66
		7/0	53.5
		8/0	44
		9/0	36
		10/0	23.6

ambiguously record their methods and to translate between systems that are in common use. Finally, we wish to encourage researchers to publish SI equivalent units with their sample preparation methods (SI refers to "Système International" units, the modern version of the metric system and the standard for scientific writing).

REFERENCE YOUR STANDARD—AND ANNOTATE WITH SI UNITS

For the dendrochronological community, the question is what needs to be communicated when we report our sample-finishing methods. If the goal is to allow other researchers, especially inexperienced ones, to understand and replicate our techniques, we are falling short of the mark, because for example finishing a surface with European "400-grit" sandpaper may still leave grooves in the wood that could mask the ring boundaries or important ring features that aid in visual crossdating. The fineness of the finish on samples is an important aspect of replication, determining how well one can discern cellular structure and the architecture of the wood under the microscope. In today's international scientific world, it makes little sense to describe one's methods in terms that are place- and time-specific.

Fortunately, the problem is easily addressed and the intended goal easily achieved. We suggest that when discussing their sanding methods, authors (and editors) in dendrochronology at the very least state (and request that authors state) what standard of grit measurements their numbers reflect. We also urge them to include (and request) SI equivalents. Doing so is good science—a basic tenet of scientific reporting is that you should include all necessary information to allow someone else to replicate your methods in another lab, or at a later time—even centuries later.

The different grit grading systems all have precise meanings—they are based on explicitly defined standards set by the respective regulating bodies. For example, in the United States the Coated Abrasives Manufacturers Institute (CAMI, now merged into UAMA, the Unified Abrasives Manufacturers' Association) originally defined the U.S. Standard Scale later adopted by the American National Standards Institute (ANSI), while the present pan-European system is regulated by the Federation of European Producers of Abrasives (FEPA). Standards differ in important ways other than the mean particle sizes we report in Tables 1 and 2. For example, there may be differences in the permissible range of particle sizes within a grade, or in the permissible degree of variability of particle sizes around the nominal size.

Correctly stated, a grit size reference should include three parts: (1) the standard used to manufacture the grit (*e.g.* ANSI in the U.S.); (2) the grade within the standard (*e.g.* 400-grit); and (3) the SI equivalent measurements of mean or included-range grit size dimensions (*e.g.* 20.6–23.6 μm). For example, "We sanded our sections beginning with ANSI 60-grit (250–297 μm) sandpaper, and used progressively finer sizes, ultimately finishing with ANSI 400-grit (20.6–23.6 μm)." Ideally, researchers will eventually be able to adopt a uniform standard. We recommend using abrasive paper manufactured to the ISO standard when a choice exists, as that standard is likely over time to grow in use among manufacturers.

Mentioning the *beginning* grit size used in the sanding process is important information for new initiates in dendrochronology. Cross sections with deep chain saw cuts will often require ANSI 24-

grit (707–841 μm) or ANSI 36-grit (500–595 μm) sandpaper to remove the grooves if no band saw or electric planer is available to create a flat initial surface. Increment cores from pines and other conifers can often be sanded initially with ANSI 100-grit (125–149 μm) or ANSI 120-grit (105–125 μm) sandpaper, while cores from hardwoods may require an initial surfacing with ANSI 80-grit (177–210 μm) sandpaper.

GRIT VERSUS FINISH

The difference between appropriate grits for hardwoods and softwoods reflects the fact that the actual finish you achieve using a particular sandpaper grade also depends on factors other than grit size. It is for this reason that the finishes of machined and cast solid materials are defined by measuring their surface roughness, as discussed above. While it's not practical to do that in sectioned wood, we believe that given a particular type of wood and a particular grade of sandpaper, different experienced workers will tend to achieve very similar finishes when hand-sanding or when using similar equipment. We acknowledge, however, that this is not guaranteed, and there are other factors involved.

First, the amount of abrasion depends on the hardness of the wood—the harder the wood, the smaller the scratches and grooves made by the grit. The second factor concerns the amount of pressure applied to the surface, which often depends on the person doing the sanding. Greater pressure produces deeper abrasions. Third, the finish also depends on how well-used the sandpaper is. Most sanding belts (and sanding sheets and finishing films) are not inexpensive, necessitating their extended use and occasional cleaning with commercially available belt cleaners (typically large sticks of gummy rubber). As sandpaper is used, the grit both dulls and fractures, the rate depending partly on the grit material (aluminum oxide, garnet, *etc.*) and its original sharpness, so that over time it produces shallower abrasions and a smoother surface.

SUMMARY

Communicating the sizes of abrasives we use, in such a way that anyone else can immediately understand our methods and replicate them at will, is an easily achieved and important aspect of scientific rigor. Hopefully, the information in this report puts that practice easily within our capabilities.

USEFUL WEB RESOURCES REGARDING ABRASIVES STANDARDS

National Resource for Global Standards: http://www.nssn.org

American National Standards Institute: http://www.ansi.org

International Organization for Standardization: http://www.iso.ch

Federation of European Producers of Abrasives: http://www.fepa-abrasives.org

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ADDENDUM

At press time we received new information from the Association of Producers of Abrasives (APA) of the Russian Federation that elucidates the situation in the former USSR. In recent decades sandpaper has been manufactured with grit size classes defined according to the GOST 3647-80 standard (Table 3), but a new Russian standard will be implemented in 2003 that will march the ISO(86) and ISO(77) standards.

Table 3. Former U.S.S.R.

GOST 3647-80 Grit size	μm	GOST 3647-80 Grit size	μm
80	800-1000	M40	28-40
63	630-800	M28	20-28
50	500-630	M20	14-20
40	400-500	M14	10-14
32	315-400	M10	7-10
25	250-315	M7	5-6
20	200-250	M5	3-5
16	160-200		
12	125-160		
10	100-125		
8	80-100		
6	63-80		
5	50-63		
4	40-50		
3	28-40		