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Re: 3D printing applications

In EPC Exhibit 136-12.1, we provided for 3D printers in an expansion at 621.988:

621.98	Pressing equipment, impressing equipment, molding equipment, additive manufacturing equipment
	Standard subdivisions are added for pressing, impressing, molding, additive manufacturing equipment together; for pressing equipment alone
621.988	Additive manufacturing equipment
	Class here three-dimensional printers

For much of the current literature on 3D printing, this development is sufficient. Consider, for example, its suitability for the following comprehensive works on three-dimensional printing:

Title	Summary
3D printing	As they become more common and more powerful, 3D printers are allowing makers everywhere to bring their ideas to life. Readers will discover new processes, integrate visual information with text, and learn technical word meanings as they discover how 3D printers work and how makers are using them today. They will also learn how to create their own inventions from 3D computer models.
Getting started with MakerBot	Provides information on using the MakerBot printer to create a wide variety of 3D objects.
Fabricated: the new world of 3D printing	This book tells the story of 3D printers, humble manufacturing machines that are bursting out of the factory and into schools, kitchens, hospitals, even onto the fashion catwalk. The book describes the emerging world of printable products, where people design and 3D print their own creations as easily as they edit an online document. A 3D printer transforms digital information into a physical object by carrying out instructions from an electronic design file, or "blueprint."
3D printing for dummies	3D printing is no longer just a figment of your imagination. This remarkable technology is coming to the masses with the growing availability of 3D printers. 3D printers create 3-dimensional layered models and they allow users to create prototypes that use multiple materials and colors. This friendly-but-straightforward guide examines each type of 3D printing technology available today and gives artists, entrepreneurs, engineers, and hobbyists insight into the amazing things 3D printing has to offer. You'll discover methods for the creation of 3D printable objects using software, 3D scanners, and even photographs with the help of this timely For Dummies guide.

But consider by way of contrast the following:

Title	Summary
Clarks brings digital touch to traditional shoemaking	Thanks to 3D CAD software and 3D printers, Clarks has moved from hand-drawn sketches and factory-manufactured samples to creating prototypes in a digital world, decreasing costs and improving its time-to-market agility.
Rapid prototyping of ceramic objects	Presentation on ceramic 3D printing, with a demonstration and a discussion of its uses and implications.
Parts just add up	Additive manufacturing promises rotorcraft makers and other aerospace companies time savings and flexibility to make innovative parts in prototype batches and production quantities.
Developments in digital print technology for smart textiles	This chapter outlines developments in digital print technology and highlights the ways in which these are significantly influencing the design and manufacture of printed textiles. Direct and non-direct methods of digital ink-jet printing, including dye sublimation and pigment printing, are explained along with the various types of print heads used. Three-dimensional digital print technologies are also described

By the rule of application, literature on the use of 3D printing in the design and manufacture of specific types of objects should class with the type of object. Would it be desirable to have the number also reflect the 3D printing aspect of the subject? (This potential need was brought to our attention by LC classifier Mark Behrens.)

In considering how to treat 3D printing applications, we have identified three options:

- Do not add further; that is, do not reflect the 3D printing aspect of the subject in any way
- Add T1—028; that is, reflect the 3D printing aspect of the subject in only the most general way
- Add a subdivision of T1—028 that would reflect the 3D printing aspect of the subject explicitly

The first option reflects the perspective that the means used to produce an object is not routinely reflected in the class number and also should not be reflected in the case of 3D printers. While 3D printing is reasonably innovative at present, it probably will not be considered innovative over the long haul. Capturing 3D printing applications in Dewey numbers will therefore not be useful / is not desirable.

The second option reflects the perspective that 3D printing is already in standing room at T1—028. The second set of works mentioned above highlight the 3D printing aspect. If a work highlights that aspect, we should also have a means of highlighting/reflecting 3D printing in the work's class number. This can be done by adding T1—028 to reflect the status of 3D printing as an auxiliary technique/procedure.

The third option reflects the perspective that 3D printing is a hot topic. Users may want to find all works on applications of 3D printing. Such a class number search could be supported only if 3D printing applications are reflected explicitly in the class number.

Given the potential argument that 3D printing applications are already in standing room in T1—028, the first option would call for the following note to be added at 621.988:

621.988 Additive manufacturing equipment
 Class here three-dimensional printers
 Class additive manufacturing applications in a subject with the subject without adding notation T1—028 from Table 1, e.g., three-dimensional printing applied to creation of costume jewelry as artistic work 745.5942

The second option would be implemented with a note at the same location, but with diametrically opposed directions regarding T1—028:

621.988 Additive manufacturing equipment
 Class here three-dimensional printers
 Class additive manufacturing applications in a subject with the subject, plus notation T1—028 from Table 1, e.g., three-dimensional printing applied to creation of costume jewelry as artistic work 745.5942028

The third option, which was our original inclination, would require not only an expansion / new notation; indeed, it turns out to be a rather complex option, as is illustrated in the appendix

In options 2 and 3, we can foresee the desirability of using 745.5 and its subdivisions as base numbers. However, the definition note at 745.5—“Creative work done by hand with aid of simple tools or machines”—doesn’t quite fit. If 3D printing is used, the work would not be done by hand, nor would it be appropriate to describe a 3D printer as a simple machine. We believe that rewording the definition note as follows may capture the needed characterization of handicrafts:

745.5 Handicrafts

Creative work done by individuals ~~hand with aid of simple tools or machines~~

Including work in bread dough

Class home (amateur) workshops in 684.08; class interdisciplinary works on handicrafts in 680. Class the handicraft aspects of another form of art with the art, e.g., printmaking using rubber stamps 761

For decorative coloring, see 745.7; for floral arts, see 745.92

See Manual at 680 vs. 745.5

We recommend implementing the second option, which includes the addition of the note at 621.988 and the change to the definition note at 745.5.

Regardless of the option chosen, we will make the corrections shown below for 669.95028:

669.950 28 ~~Specific kinds of techniques and procedures; apparatus, equipment, materials~~ Auxiliary techniques and procedures; apparatus, equipment, procedures
Notation 028 from Table 1 as modified below

Appendix

This appendix documents what the third option—in which 3D printing applications (and indeed much more) would be reflected explicitly in the class number—would involve. It captures the discussion in a previous version of this exhibit, in which only this option was under consideration:

The first question is whether the numbers to which we would want to add notation for 3D printing are confined to a limited span of numbers or whether we would need to provide for notation in Table 1. In general, all manufactured physical objects (throughout the 600s) could be the products of 3D printing. We also envision the products of 3D printing being considered as works of artistic expression (throughout the 700s). We therefore look for a Table 1 solution.

A second question is whether it is possible to use some existing mechanism to bring out the 3D printing aspect of the titles above. For example, since a number has been established for additive manufacturing equipment / 3D printers, could we use T1—0284 Apparatus, equipment, materials? The answer is no, because the scope note at T1—0284 limits the number to “apparatus, equipment, materials used in a subject.” But 3D printers are not equipment used in / relevant to a specific subject. Moreover, the class-elsewhere note—“class products of a subject in 001–999 without adding notation 0284 from Table 1”—tells us that we wouldn’t add T1—0284 for products in a subject anyway. Then what about T1—0285 Computer applications? But 3D printers themselves are not part of 004–006, so the add instruction would not apply; this option would give us no mechanism for specifying 3D printing.

A third question is whether we need to provide for manufacturing processes broadly, or just for 3D printing, or for some (“just right”) specific subset of manufacturing (or more broadly, engineering) processes (the latter possibility being favored by the Goldilocks principle). We can dispense with the need to provide for manufacturing/engineering processes broadly based on the many numbers in the DDC for manufacturing processes in the context of the material worked with or the product made (e.g., 671.2–671.7 Specific metalworking processes; 676.122–676.127 (Pulp) Specific processes; [678.2 Rubber] 678.22 Mastication, 678.23 Compounding, 678.24 Vulcanization, 678.27 Molding, extruding, calendaring. Providing for manufacturing processes broadly would result in massive dual provision.

This leads us to the general picture that manufacturing/engineering processes that are in some sense conventional, say, in producing certain materials, products, etc., are to be provided for in the contexts of those materials, products, etc.; the only manufacturing/engineering processes that would need to be provided for in a Table 1 development are those not taken care of by developing for the processes that are conventional in a subject. That is, at least conceptually, we start with the materials, products, etc., not with the processes; conversely, we need to look for manufacturing/engineering processes outside developments for materials, products, etc., for example, processes outside 670 and 680.

To do so, we searched for LCSHs that had been editorially mapped to DDC numbers outside 670 and 680 and that have as a broader term “Manufacturing processes.” The search retrieved four LCSHs in the 620s (Lead-free electronics manufacturing processes, Mills and mill-work, Rapid tooling, Three-dimensional printing) and three LCSHs in the 660s (Chemical processes, Finishes and finishing, Injection metallurgy). Straightforward interpretation of these results would, however, lead us astray. For one thing, the LCSH Lead-free electronics manufacturing processes also has a 550 field for Green electronics and is already covered by T1—0286 Green technology (Environmental technology). For

another, the LCSH Injection metallurgy is mapped to 669.0282, a “conventional” process for metals, so even though it is outside 670 and 680, it isn’t what we are looking for; the other two LCSHs mapped to numbers in the 660s, however, are. Thirdly, and ironically, the LCSH Three-dimensional printing does not have Manufacturing processes as a broader heading. We don’t have a search index specific to 550 fields; therefore the broader-term aspect of the search had to be implemented as a keyword search. One of the 670 fields in the Three-dimensional printing record includes this statement: “3DP is one of a number of manufacturing processes in the larger field of rapid prototyping.” We see that we can’t count on the presence of a 550 field for Manufacturing processes. Even though we can therefore assume that the results are not comprehensive, we have sufficient evidence to see the potential need to add for at least some manufacturing processes besides 3D printing. Indeed, we could imagine wanting to add for engineering applications generally (although in many cases, the applications of a kind of engineering are likely to be limited to a particular discipline; for example, applications of biomedical engineering are likely to be classed only in the 610s, while applications of agricultural engineering are likely to be classed only in the 630s).

We need to limit the use of the new provision in two ways:

- The provision should not be used for conventional engineering applications.
- We want to minimize the chances of dual provision.

We provide a Manual-like note to communicate these limitations.

Our best strategy is to start with notation subordinate to T1—028. Two obvious possibilities are the unused notations, T1—0282 and T1—0283. Both, however, have been used in special developments, including special developments under numbers in the 600s and 700s. Maneuvering around dual usage of such notation could be messy, which leads us to revisit the question whether it is possible to use some existing mechanism to bring out, not only 3D printing applications, but engineering applications in general. In particular, we are led to wonder about the feasibility and desirability of broadening the meaning of T1—0286 Green technology (Environmental technology) to become T1—0286 Engineering applications.

We investigated the use already made of T1—0286 Green technology by searching in WorldCat for su:“Green technology” with DDC numbers in the 00s, 300s, 500s, 600s, and 700s and then scanning the DDC notation for T1--0286. The searches retrieved 125 records (but only 36 works) using T1—0286, almost all in the 600s. Works on green computing, green communications, green IT, and green networking were, however, routinely classed in numbers outside the 600s. We note that T1—0286 includes no limitations on its use as we propose to impose on the use of standard subdivision notation for engineering applications generally. This difference makes the use of T1—0286 less attractive, and we return to the possible use of T1—0282 or T1—0283, plus notes needed in the context of special developments.

Here we adopt T1—0282. We add notes to clarify that other engineering applications (as expressed by T1--0286–T1—0289) are preferred over the new notation and provide a Manual-like note that borrows heavily from those present in T1—0287 and T1—0288.

In response to such a proposal, Juli Beall shared the following thoughts: “T1—028 is much higher in the table of preference than T1—022, but the rule of application—and maybe also the “not provided elsewhere” part of the scope note—would say that 3D printing etc. applied to making models and

miniatures would go in T1—0228; nevertheless, I wonder whether there is something else we can do to help people? My guess is that 3D printing will be used for all kinds of models and miniatures.” Here we believe that the general principle underlying the T1 table of preference should prevail, so we propose a note at T1—0228 Models and miniatures to draw off model and miniature engineering applications.

T1—022 8 Models and miniatures

Class simulation models in —011; class model and miniature engineering applications in —0282; class model and miniature educational exhibits in —074; class interdisciplinary works in 688.1

T1—028 Auxiliary techniques and procedures; apparatus, equipment, materials

Class laboratory manuals in —078

For research methods, see —0721

T1—028 2 Engineering applications

Limited to applications not clearly associated with a subject and not provided for elsewhere; use this subdivision only with numbers denoting design, fabrication, manufacture, construction, installation, or artistic work, not with numbers denoting use, operation, or application when these are different

Class interdisciplinary works on engineering in 620

Add to base number —0282 the numbers following 6 in 600–690. e.g., three-dimensional printing applications —028221988, three-dimensional printing applied to creation of costume jewelry as artistic work 745.5942028221988

For green technology applications, see notation –0286 from this table; for testing and measuring instrument applications, see notation –0287 from this table; for maintenance and repair applications, see notation –0288 from this table; for safety engineering applications, see notation –0289 from this table

...

➤ ~~T1—028 5 028 9 Auxiliary techniques and procedures~~

~~Class laboratory manual in —078; class comprehensive works in —028~~

~~*For research methods, see —0721*~~

502.82 Microscopy

Do not use for engineering applications; class in 502.8

Including photomicrography, stereology

Class here microscopes; interdisciplinary works on microscopy

Class interdisciplinary works on photomicrography in 778.31

For manufacture of microscopes, see 681.413. For microscopy in a specific subject, see the subject, plus notation 028 from Table 1, e.g., microscopy in archaeology 930.1028

- 570.282 Microscopy
Do not use for engineering applications; class in 570.28
Including photomicrography, stereology
Class here microscopes
Class interdisciplinary works on microscopy in 502.82
- 665.028 2 Extraction
Do not use for engineering applications; class in 665.028
Including pressurizing, rendering, steam distilling
- 669.028 2 Pyrometallurgy
Do not use for engineering applications; class in 669.028
Extraction by furnace methods, e.g., smelting
Class electrical zone melting in 669.0284
- 669.950 28 ~~Specific kinds of techniques and procedures; apparatus, equipment, materials~~ Auxiliary techniques and procedures; apparatus, equipment, procedures
Notation 028 from Table 1 as modified below
- 669.950 282 Microscopical metallography
Optical and electron metallography
Do not use for engineering applications; class in 669.95028
- 748.202 82 Glassblowing
Do not use for engineering applications; class in 748.2028
- 748.502 82 Glass painting and staining
Do not use for engineering applications; class in 748.5028
- 799.202 82 Blowpipes, bolas, boomerangs, lassos, nets, slings, spears
Do not use for engineering applications; class in 799.2028
- 930.102 82 Discovery of remains
Do not use for engineering applications; class in 930.1028