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Structured Interview Guide and Template for Specification of Woody Biomass Fuel and Feedstocks

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***Abstract*.** Lack of full technical specification for biomass fuels and feedstocks is a major source of confusion, uncertainty, and conflict throughout the supply chain. With support from US Department of Agriculture and US Department of Energy, we have interviewed scores of industry participants and reviewed both the scientific and commercial literature to develop a template for specification of biomass materials. The resulting structured interview guide and template for documenting specifications can be situationally modified for various feedstocks, conversion processes and end products. The template emphasizes physical properties, biogeometric dimensional properties, and anatomical content.

Keywords. *Biomass, forest, bioenergy, quality, standards*

Introduction

A hot shot newly minted forest engineer listens in on a negotiation between a logging contractor and biofuels feedstock buyer. This is what the engineer hears.

> Q: “What size do you want?” A: “Three inch minus, but not too much fines and no sticks.”
>
> Q: “How wet can the loads be?” A: “Dryer is better. Water running out the bottom of the truck is bad.”
>
> Q: “How barky can it be?” A: “We want clean chips. If we can see the bark in it, there is probably too much.”

The conversation progressed in much the same manner for another twenty minutes before the deal was done. The young engineer’s boss then turned to her and told her to inspect the first three truckloads to be delivered from this new supplier to ensure they meet the specs just agreed to.

Over the past ten years, the engineers at Forest Concepts have listened in on similar conversations and organized structured interviews to develop methods for translating natural language descriptors into more technical specifications. In the process, we have educated both biomass suppliers and buyers about the implications of imprecise terms (e.g., wet, dry, clean, dirty, etc.) on the value of biomass feedstocks.

Since 2005, under funding from US Department of Agriculture and US Department of Energy, Forest Concepts has been developing and refining a structured process and format for specification of biomass raw materials and feedstocks. Various drafts and iterations have been presented at conferences and tested with industry participants. This paper is based on the content of continuing professional development workshops being delivered by the engineers at Forest Concepts, LLC.

Clear and concise specification and assessment of biomass raw materials and feedstocks is important for efficient commercial transactions between suppliers and customers. It is equally important for designers and operators of biomass handling, processing and conversion facilities. Uncertainty and vagueness drive up costs and risks at all stages of the supply chain and conversion process.

There are numerous standards and standard methods published by ASABE, ANSI, ASTM, ISO, US DOE/NREL, and other organizations that relate to biomass materials and feedstocks. Subtle differences between seemingly identical standards and methods can lead to big differences in product quality. Thus, choice of standard for analysis is an important part of the specification in many aspects of feedstock supply agreements.

We are publishing this protocol and interview structure to stimulate further discussion within the biomass research community and bioenergy industry. The complete current form is included as an appendix to this paper. A next step will be to develop an interactive workbook and web-based form to enable more formal structure to biomass feedstock specifications and transactions.

The protocol is specific to woody biomass and feedstocks. In some sections, we have added content that covers herbaceous crops and agricultural residues. However, we expect that additional development will be needed for versions applicable to unique biomass sources and conversion processes.

General Organization

The organization of the specification template is designed to follow a logical pathway from the material itself to delivery and business issues. The ordering of content is influenced by the natural order of conversation we have observed during negotiations between biomass suppliers and buyers.

The top level headings in our protocol are as follows:

- Front Matter
- Particle size
- Particle shape
- Moisture content
- Freshness/material age
- Anatomical content
- Species content
- Contaminants
- Ash content
- Bulk density
- Flowability
- Air flow resistance
- Proximate analysis
- Ultimate analysis
- Delivery methods
- Scaling of deliveries
- Receiving quality sampling
- Rejections and penalties
- Basis of payment
- Chain of custody and traceablity
- Natural language definitions and heuristics
- Applicable standards
- Other specifications

We will go through each of these topical areas to introduce and discuss how the term may be appropriately detailed and defined as part of feedstock specifications. It is important to note that not all of the areas and detailed content is needed for most biomass supply contracts. However, engineers and negotiators should be aware of all the content so context-appropriate terms and conditions can be established.

Document Number:		
Biomass User / Customer		
	• **Customer ID / Vendor No:**	
	• **Name:**	
	• **Phone:**	
	• **Email:**	
	• **Website:**	
	• **Person interviewed:**	
Conversion process and/or end use		
General Description of Biomass Material		e.g., Hog fuel, clean chips, dirty chips, micro-chips, sawdust, logs, stover, msw, …
Units of Measure		e.g., U.S. / Metric / SI

Good recordkeeping practices call for a complete identification of the parties doing the specification and will be involved in the resulting biomass transaction.

Knowing the conversion process or end use that a biomass customer will apply to the material provides useful information that a knowledgeable supplier can use to fill in the blanks where the customer does not know an answer or to use as a test to identify those specifications that are stated by a customer, but are likely to be inappropriate or outside the range of norms.

Similarly, the natural language description of the biomass material being specified provides clues to the range of applicable specifications. Within a narrow geographic area the general meaning of terms such as clean wood chips, hog fuel, whole tree chips, etc. has a meaning.

Finally, a supplier and customer need to be on the same page as to the units of measure throughout the transaction. It is often not obvious whether a specifications, measurements, weights, etc. should be in English units, SI units, or metric units.

Particle Size

Particle Size		
	Particle size - Maximum	
	• **Length**	
	• **Width**	
	• **Thickness**	
	Must pass sieve opening	
	Particle size - Minimum	
	• **Length**	
	• **Width**	
	• **Thickness**	
	No-pass sieve opening	
	Geometric mean diameter – acceptable range	
	Uniformity within a lot	
	Uniformity lot-to-lot	
	Sieve analysis test method – standard to be followed	

Particle size is most often specified by a sieve opening that all of the material must pass through (e.g., “3-inch minus” means that all the material must pass through a sieve or screen with a 3-inch opening) What is not stated is whether the sieve has square, round, hexagon, or other shaped openings. Biomass particles tend to have a high length to width ratio which means that particles are typically much longer than their sieve analysis suggests.

Thus, we propose that length, width, and thickness each be specified. To be biogeometrically correct, the length is always specified as the distance parallel to the natural grain of wood or fibrous stalk of the plant material. Width and thickness are then measured at right angles to the axis that defines the length. The following definitions may be helpful.

Biogeometry - Descriptive shape and dimensions of a biological object such as wood chip, ground corn stover, etc. where the datum and orientations are determined relative to biological features. For example, in the case of fibrous stalks and woody materials length is always measured along the dominant fiber grain.

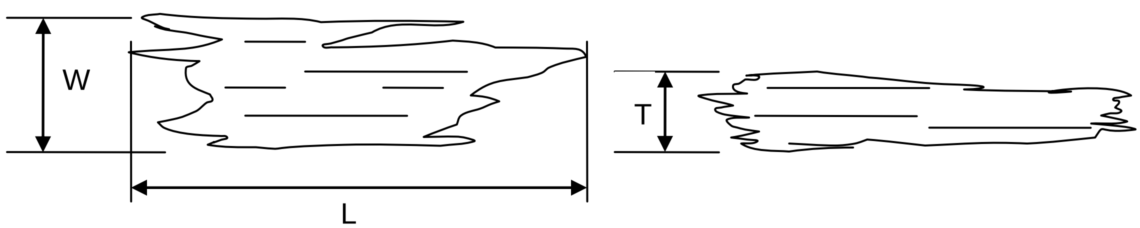

Figure 1. Particle length (L), width (W), and thickness (T) are measured with respect to grain and natural biological structure of the material.

Length (L) – The maximum dimension parallel to grain. For an irregularly shaped particle, length is defined by the minimum distance between parallel vertical faces within which the particle will fit. This term may also be called the *extents length*.

Width (W) – The maximum dimension normal to length and perpendicular to grain. For an irregularly shaped particle, width is defined by the minimum distance between parallel vertical faces oriented parallel to grain within which the particle will fit. This term may also be called the *extents width*.

Thickness (T) – The maximum of the third dimension at right angles (normal) to both length and width once the length and width are identified.

For different conversion processes and uses, one or more dimensions may be important. Several operators of fast pyrolysis biofuel facilities simply specify that their feedstocks “must not exceed 2mm in any one dimension.” It does not matter to them whether the 2mm dimension is length, width or thickness.

The companion to maximum particle size is specification of minimum particle size limits. In natural language terms, minimum limits are described as “fines.” Interestingly, the term “fines, may mean anything with a cross section less than 250 microns to one buyer and less than 10 mm to another. Thus, it is important to specify minimum biogeometric dimensions if possible, and/or a “no-pass” sieve size specification.

One hog fuel producer has a fuel specification that states all their woody biomass-derived fuel has particles that will pass through a 2-inch (50 mm) round hole orbital screen and be retained on (not pass through) a ¾-inch (16 mm) round hole orbital screen. Another may specify that their material will pass through a 3-inch wire trommel screen and not pass through a ½-inch wire trommel screen. These two materials will have very different material handling and conversion performance.

If a particular type of sieve (trommel, orbital, vibratory, finger, disk, etc.) is relevant and part of the specification then that should be included in the description of sieve tolerances. Similarly if a particular sieve opening shape is important, that should be specified as well. Lacking specification of a context-specific sieving method, there should be agreement as to standard methods to be used as defined by ASABE (e.g., Standard 319 vs. 424) or other ISO, ASTM standard.

Beyond specification of the dimensions and/or sieve properties for a material, there are other metrics that may be useful to specify. Since actual particle size of each member of the population of particles in a lot is a continuum (typically highly skewed), it may be useful to include population statistics in the form of a geometric mean dimension rather than an absolute dimensional limitation.

Another size related issue is that of uniformity both within a delivery and across time. What is the allowable coefficient of variation or standard deviation for multiple samples within a lot, or between deliveries over time?

Particle Shape

Particle shape has profound effect on materials handling, flowability, and other factors that are important to the design and operation of supply chain and biofuel conversion facilities.

Particle shape	**e.g., chips, shreds, shards, sticks, stalks, flakes, shavings, strings, cubes, chunks, chopped, etc**

Particle shape is in-part a result of comminution methods such as chipping or grinding. However, the distribution of shapes within a lot of biomass materials is also affected by how comminution equipment is maintained and operated, as well as the raw biomass material being processed.

The distribution of particle shapes within a biomass sample can be determined by inspection, and eventually will be able to be analyzed electronically.

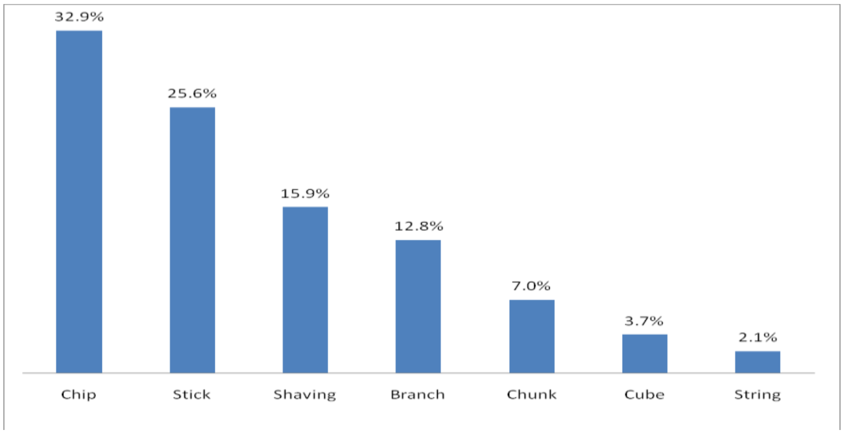

Figure 2. Distribution of particle shapes by count within a sample of wood fuel chips.

The figure above demonstrates the information value of particle shape analysis. This data is from a commercially delivered truckload of wood chips delivered to a biomass power plant. The chips were produced by a disk chipper processing whole trees, tops, and limbs at a logging site. The material had been debarked prior to chipping.

Moisture Content

One would think that allowable moisture content is easy to specify. The first source of confusion is whether moisture content is to be reported on a wet weight basis or dry weight basis. Most agricultural commodities are reported on a wet weight basis while most forest commodities are reported on a dry weight basis. The implication is that 50% MC is really wet to a hay grower and reasonably dry to a sawmill. Green logs are typically 110% MC (db) to a saw mill, which is considered an impossibility to someone from agriculture who is used to wet weight basis where 100% MC(wb) is pure water. We suggest that moisture content be specified and reported on a wet weight basis for all biofuels and bioenergy related transactions, even though the US and ISO standards allow for both wet and dry basis.

Moisture Content		
	Preferred moisture content (wwb)	
	Maximum allowable MC	
	Minimum allowable MC	
	Uniformity – allowable range within a lot/load	
	Allowable rate of variance over time	
	Allowable free water/drain water content	
	Allowable snow and ice content	

Both maximum and minimum allowable moisture content are relevant to biomass feedstocks. Higher moisture content reduces the net energy yield in thermal conversion processes, and increases the water content of bio-oil in pyrolysis oil production systems. In contrast, low moisture content causes problems in some biochemical conversion processes due to induce recalcitrance and/or slows absorption of liquid pretreatment chemicals. Then there is the obvious issue of short storage life for high moisture baled biomass materials.

Some processes such as gasification are fairly tolerant of a range of feedstock moisture levels, but are very sensitive to rapid swings in moisture. One equipment supplier limits moisture variance to plus or minus 5% wb within a biomass lot and a seasonal rate of change of the mean moisture content across deliveries of no more than 10 percent per month.

In areas where severe storms affect forest harvesting operations and where biomass feedstocks are delivered in trucks loaded from open piles at aggregators there can be a problem of either free water draining from trucks or large clumps of snow or ice within loads. Free water draining from trucks during delivery can cause receivers to exceed their stormwater discharge quality permit limits. Excess water, snow, or ice also contributes tonnage to loads that has no value to the receiver. Thus, loads may be rejected for high moisture, free water, snow or ice content in some cases or the price paid for the load will be reduced due to deductions or penalties.

Freshness / Material Age

Freshness matters in sweet corn, catfish, and to someone practicing biochemical conversion of high sugar content feedstocks, freshness matters to them as well. On the other hand, natural air drying of coniferous feedstocks reduces transportation costs and increases net energy content. Thus, conversations about feedstock requirements should include a discussion about freshness and age of materials.

Freshness / Material age		
	Time since harvesting	
	Greenness	
	Color, brightness, sun aging	
	Storage requirements from time of harvest (indoor, outdoor…)	
	Minimum moisture % since harvesting	

The amount of time between harvesting and delivery or conversion may be an indicator of the amount of colonization by rot fungi, breakdown of bark or leaves, loss of volatile organic compounds, and many other factors that positively or negatively affect downstream processs.

As discussed earlier, some biochemical processing systems, and even premium grade wood pellet producers often pay a premium for bright fresh feedstocks. The extent of sun aging may affect value for pellet manufacturers.

Although not important to many customers, outdoor storage of chipped or even baled biomass in very dry environs can result in moisture content of less than 5% wb for some times of the year. This may make the material recalcitrant for biochemical conversion or otherwise affect densification or conversion even after rehydration.

Anatomical Content

Across nearly all types of biomass feedstocks, buyers tend to have strong opinions about the value or cost of various anatomical components of the feedstock they are buying. Although baling, chipping, chopping, or grinding whole plants is preferred by biomass producers, the negative implications of each anatomical component are increasingly understood for specific conversion processes.

Higher ash content of bark and leaves may exceed the allowable limits for pellet production and lead to high char production during thermochemical conversion of biomass to liquid biofuels. In other cases, stringy bark can result in fiber balls or other pluggage in materials handling and processing equipment.

Anatomical Content		
	Wood (bole/branch wood)	
	Bark	
	Leaves & needles	
	Fruit, cones, nuts, cobs, seeds, etc.	
	Pith	
	Roots or root wood	
	Fiber balls or wads in ground feedstocks	

As noted in the above listing, buyers and sellers should work though a complete list of the potential anatomical content for a feedstock and agree on limits where appropriate.

Species Content

Species, variety, or clone (genotype) may or may not be important to buyers of biomass feedstocks depending on their processes and end use. It is well known that hardwood and softwood feedstocks require different pretreatment processes in biofuel facilities. Pellet manufacturers typically market softwood and hardwood pellets under different brands or to different markets. As biofuels production matures, there is already discussion about genotypic optimization of pretreatment and fermentation processes.

Species content		
	Softwood	
	Hardwood	
	Brush species	
	Undesirable species	
	Variety or clone limitations	

Specification of species may either be stated positively (e.g., ponderosa pine only) or negatively (e.g., no locust or walnut). Where biomass is produced from urban street tree trimmings, land clearing activities, forest management, or roadside and utility corridor vegetation management there is little control over the species mixture.

In some cases a buyer will want the supplier to note on all delivery documents the predominant species that were growing on the site being harvested and the presence of potentially dangerous content from chipped poison oak and related toxic species.

Contaminants

Contaminants in loads of biomass raw materials or feedstocks may be of minor impact or may pose serious safety and process risks. It is difficult for biomass suppliers to provide absolutely clean loads when the normal supply chain includes piling stocks on bare soil and gravel pads, hauling in trucks used for other commodities, etc. There is a general acceptance that the price bioenergy firms are willing to pay for feedstocks does not support food grade GMP in the supply chain.

Contaminants		
	Organic contaminants	
	• **Decayed or moldy**	
	Inorganic contaminants	
	Allowable % soil, sand, gravel, rock	
	Allowable % abrasive grit (4-100 mesh)	

Many supply contracts include statements that limit visible mold or decay and significant amounts of dirt, gravel and rock. Whether the level of contamination is acceptable or not is usually left to a debate between the receiving person and the truck driver. It is far more useful to establish numerical limits on contaminants, including “none,” and a stated method for auditing loads as they are received.

Inorganic contaminants increase the ash production in boilers which may increase risks of slagging and plugging. Soil contamination in wood chips or baled agricultural residues may include calcium, iron, sodium, and other compounds that catalyze undesirable reactions during processing.

Many power plants and pellet mills have established limits on the total ash of their feedstocks resulting from the material itself and any inorganic contaminants.

Many pellet manufacturers and most forest products manufacturers limit the amount of “abrasive grit” that accelerates the wear of their equipment. Where abrasive grit is to be limited, there must be a designation of the definition of sieve size as well as amount. A common sieve definition of abrasive grit is all the inorganic material that passes a No. 4 screen and is retained by a No. 100 screen.

Ash Content

As noted above, ash content typically includes both the inherent ash resulting from the biomass feedstock and any ash resulting from inorganic contaminants. Ash content of pure commodity feedstocks such as rice straw, corn stover, clean pine chips, and the like are available from published sources. Ash content of mixed loads, commingled whole tree chips, urban waste, and the like can be highly variable between loads and within loads.

Ash Content		
	Maximum ash	
	Minimum ash deformation temperature	
	Allowable alkali index	

A subset of the specification of ash limits, particularly for thermal and thermochemical processes, is a specification of the minimum ash deformation temperature and allowable alkali index.

Bulk Density

Bulk density of biomass raw materials and feedstocks is rarely a part of specifications, but is an important number for process and facilities designers to know. Bulk density is typically measured using standard containers following standard methods. Where bulk density is part of a specification or part of the information that buyers expect suppliers to provide, it is important to have an agreement as to the moisture content at time of bulk density determination and the method to be used.

Bulk density		
	Loose bulk density	
	Tap bulk density	

If bulk density is measured by a supplier or receiver, it is useful to measure both loose bulk density (free poured density) and tap bulk density. The ratio of the two measurements can be used to calculate the Hausner Index of flowability that will be discussed later. Bulk density numbers are also important for facilities that store raw materials or feedstocks in silos and reclaim towers since it enables estimation of inventory from the volume of material in storage.

Flowability

A great many factors affect the flowability of biomass materials or organic feedstocks. Flowability is a complex outcome of particle size, shapes, heterogeneity, moisture content, surface texture, handling history, etc. The literature is populated with methods to measure and express flowability of various materials. For the purposes of this discussion, it is only important that buyers and sellers be aware that flowability can be measured and reported if needed. The worksheet includes a listing of the most common metrics for determination and reporting of flowability.

Flowability		
	Maximum bridging index	
	Maximum static angle of repose	
	Maximum internal friction angle	
	Hausner Index	
	Angle of drain from hoppers	
	Maximum Cohesiveness	
	Other flowability test specification	

Air Flow Resistance

The level of resistance to forced and natural air movement through a pile or bin of biomass material affects stack heating, drying, loss of volatiles, and other important storage parameters. Additionally, air flow resistance affects the performance of gasifiers, packed bed reactors, and some pretreatment processes. In order for some packed bed and gasification processes to work properly both minimum and maximum air flow resistance levels may be specified.

Air Flow Resistance		
	Minimum column resistance	
	Maximum column resistance	

	Test method	

When air flow resistance measurements or data is needed by a biomass buyer, the two parties need to agree on methods and moisture content to be used.

Proximate and Ultimate Analyses

Proximate and ultimate analyses are often required by biopower and bioenergy customers who are considering a new fuel source. The methods of analysis and reporting have been standardized by NREL and others, with many certified test labs.

Proximate analysis (acceptable range)		
	Moisture content (wb)	
	Volatile content	
	Fixed carbon	
	Ash	
	Higher Heating Value (HHV)	
Ultimate analysis (acceptable range %)		
	Carbon	
	Hydrogen	
	Oxygen	
	Nitrogen	
	Sulfur	
	Chlorine	
	Ash composition (K, Na, Cl)	
	Other elemental analysis:	

Delivery, scaling, quality assurance, and other business issues

The balance of the feedstock specification worksheets movie from specifications and limitations that relate to biomass materials and feedstocks per-se to the “stuff and things” that related to delivery, quality, and the business aspects or supply agreements. We are not going to spend reader time and attention on these issues in this conference paper. Suffice it said that delivery, scaling, quality assurance, and other elements of the supply system are important to clearly understand and document as part of a supply agreement.

Delivery Methods		
	Allowable delivery methods	e.g., Rail, barge, truck
	Truck delivery methods acceptable	
	• **Truck tilt dumper (truck & trailer, trailer only)**	
	Ground level unloading of flowable material	
	• **Pneumatic receiving**	
	• **Grated end dump or walking floor**	
	• **Grated center drive-over bottom dump**	
	Intermodal container handling	
	• **Roll-off and hook-lift acceptability**	
	• **Intermodal sea-rail containers**	
	Baled & bundled materials accepted	
	• **Round bales, square bales, bundles**	
	• **Hay squeeze used to unload (Y/N)**	
	• **Forklift for unloading (Y/N)**	
	• **Bale size limits set by handling equipment**	
	• **Bale size limits set by grinding equipment**	
	• **Bale wraps acceptable?**	
	• **Twine, strapping material limitations**	

Scaling of deliveries		
	Scale ticket from supplier with Bill of Lading	
	Scaling at receiving entrance to facility	
	• **Scale operated by driver**	
	• **Scale operated by receiving facility**	
Receiving quality sampling method		
	Test report required attached to Bill of Lading?	
	Shipper sends samples in cab of truck?	
	Driver pulls samples during unloading?	
	Receiver / scale operator pulls samples?	
	Samples pulled from unloading conveyor?	
	Sample size and protocol for sample collection	
	Who pays for which sample analysis?	
Rejections and Penalties		
	Process for rejecting and penalizing loads	

	Rejected load appeal process	
	Supplier obligations when load rejected	
	Supplier obligations when material rejected after delivery	
	Supplier obligations for cost and handling of excessive contaminants	
Basis of Payment		
	Weight basis (green tons, dry tons, bdu…)	
	Variable payment based on moisture content	
	Net BTU basis from content analysis	
	Product yield basis per unit/lot delivered	
	Documentation of deductions and rejections	
	Additions and bonuses - criteria and process (clean, low moisture, purity…)	
Chain of Custody and Traceability		
	Certification of source to what level?	
	Required disclosure of supplier lot number coding scheme?	
	Required disclosure of upstream cost, distance, methods, and other LCA data	

Acknowledgements

We appreciate the participation of Forest Resources Association members and attendees at our Biomass Feedstocks 101 continuing professional development workshops for their contributions to our supply worksheet content and definitions.

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Disclaimer

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Appendix 1

Woody Biomass, Fuel, and Feedstock Specifications Worksheet – Rev. 2011-05-18

Applicable to bulk biomass (Not necessarily applicable to pellets, briquettes, etc.)

Document Number:		
Biomass User / Customer		
	• **Customer ID / Vendor No:**	
	• **Name:**	
	• **Phone:**	
	• **Email:**	
	• **Website:**	
	• **Person interviewed:**	
Conversion process and/or end use		
General Description of Biomass Material		e.g., Hog fuel, clean chips, dirty chips, micro-chips, sawdust, logs, stover, msw, …
Units of Measure		e.g., U.S. / Metric / SI
Particle Size		
	Particle size - Maximum	
	• **Length**	
	• **Width**	
	• **Thickness**	
	Must pass sieve opening	
	Particle size - Minimum	
	• **Length**	
	• **Width**	
	• **Thickness**	
	No-pass sieve opening	
	Geometric mean diameter – acceptable range	
	Uniformity within a lot	
	Uniformity lot-to-lot	
	Sieve analysis test method – standard to be followed	
Particle shape		e.g., chips, shreds, shards, sticks, stalks, flakes, shavings, strings, cubes, chunks, chopped, etc
Moisture Content		
	Preferred moisture content (wwb)	
	Maximum allowable MC	

	Minimum allowable MC	
	Uniformity – allowable range within a lot/load	
	Allowable rate of variance over time	
	Allowable free water/drain water content	
	Allowable snow and ice content	
Freshness / Material age		
	Time since harvesting	
	Greenness	
	Color, brightness, sun aging	
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	Minimum moisture % since harvesting	
Anatomical Content		
	Wood (bole/branch wood)	
	Bark	
	Leaves & needles	
	Fruit, cones, nuts, cobs, seeds, etc.	
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	Roots or root wood	
	Fiber balls or wads in ground feedstocks	
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	Hardwood	
	Brush species	
	Undesirable species	
	Variety or clone limitations	
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	Organic contaminants	
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	Allowable % soil, sand, gravel, rock	
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	Maximum ash	
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	Allowable alkali index	

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	Other flowability test specification	
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	Minimum column resistance	
	Maximum column resistance	
	Test method	
Proximate analysis (acceptable range)		
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	Ash	
	Higher Heating Value (HHV)	
Ultimate analysis (acceptable range %)		
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	Nitrogen	
	Sulfur	
	Chlorine	
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	• **Grated center drive-over bottom dump**	
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Chain of Custody and Traceability		
	Certification of source to what level?	
	Required disclosure of supplier lot number coding scheme?	
	Required disclosure of upstream cost, distance, methods, and other LCA data	
Natural Language Definitions & Heuristics		
	"Fines"	
	"Overs"	
	"Accepts"	
	"Rejects"	
	"Clean Chips"	
	"Dirty Chips"	
	"Grit and Dirt"	
	"Sweet Spot"	
Applicable Standards (ASABE, ASTM, ISO, EN…)		
Other Specifications		

Compiled by: _ ______________________ Date: ____________________

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