

Practical Process Control for Consistent Production of Quality Compost

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This project is an initiative of the RRC, and is a representation of their commitment to resource recovery and to the production of quality compost products that meet the needs of both Council and the surrounding region.

The ROU thanks Garry Kimble for his contribution to the development of the process control forms and system defined within; particularly for his patience as we sought to define a practical system that, consistent with the classic Einstein quote, is as simple as possible but no simpler.

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1 introduction

1.1 Why is product consistency and quality important

Large scale composting is overwhelmingly practiced in Australia as the aerobic composting of non-putrescible and putrescible organic waste materials to produce a range of recycled organics products suitable for sale and beneficial use in a various of landscaping and agricultural applications.

This requires firstly that generic risks that may present in the raw materials are addressed, and secondly that the commercial risks associated with fitness for purpose of the compost products are addressed.

Large scale composting is a business, and the business objectives must prioritise the production of compost products of suitable quality for intended use. Increasingly, the commercial viability of a compost business requires production of compost products to meet published product standards, or otherwise to meet product specifications defined by the compost producer to meet the needs of specific target markets or consumers.

In both contexts, business success requires the consistent production of composts that conform to documented specifications.

The operational tools and procedures defined in this document refer to the general management of the compost pile and to compost production. Environmental regulations, site license requirements, and health and safety and other regulatory requirements should be integrated into formal operational procedures, however as these requirements vary with regional jurisdiction and individual site arrangements, such considerations are outside the scope of this document.

Note that the term "windrow" is used throughout as this is overwhelmingly the most common form of compost pile used for aerobic compost production at commercial scale across Australia. Regardless of whether batches of compost are formed in piles, bays, open windrows or other arrangement, the process control system defined in this document can be applied to achieve consistent product quality.

1.2 The first steps to compost product quality

The first steps on the path to consistent product quality are:

- a) Top management commitment to quality via a corporate quality policy;
- b) Define and document the primary target markets/applications for which compost products will be manufactured,
- c) Define and document the relevant specifications of each of these compost products (chemical, physical and biological characteristics);
- d) Establish a system for controlling the windrow composting process that enables the consistent manufacture of the base compost product of suitable qualities and that conforms to documented specifications.

This base compost product can then be screened and/or blended with other materials into products that conform to the documented specifications as required.

Regardless of the specific compost products your facility intends to manufacture, the system for controlling the windrow composting process will require management of the following key production processes.

- Identification of compost batches when formed into windrows.
- Compost windrow monitoring and management.
- Compost windrow assessment and release as suitable for sale.
- Compost batch sampling and testing by laboratory for conformance to specifications/standards.

Implementation of a specific Process Control System for these critical production processes is the scope of this current document. This Process Control System provides a fundamental basis for improvement in the consistent production of compost of known and reliable quality, consistent achievement of customer satisfaction, and management of commercial risk associated with the production and sale of compost products.

1.3 ISO 9001: Quality Management Systems

AS/NZS ISO 9001:2003 Quality Management Systems is the international standard series that defines the requirements of a Quality Management System (QMS) as documented by the International Standards Organisation, and subsequently endorsed and republished by Standards Australia and New Zealand.

Organisations use the QMS system and standard internally to manage for business success, or to work towards certification under the standard. Certification requires an organisation to meet **all** the requirements of the standard, to be audited by an appropriately accredited independent auditor, and to pay a registration plus annual fees to a registered certification body. This allows the organisation to evidence claims of compliance with the standard, and:

- To use the certification logos to evidence compliance in tenders and other proposals to better compete for business opportunities; and
- To use the certification logos to evidence compliance to access markets/customers, and to promote both products and the business.

1.4 Improved process control versus ISO 9001 QMS?

The aim of the QMS is to systematically ensure customer satisfaction and business success via the production of compost products that:

- Consistently meet the requirements of identified target markets;
- Minimise commercial risk via regulatory compliance, effective pasteurisation of materials, conformance with standards, labelling and product information, and suitability of product for intended application;

- Consistently meet product quality standards (either published standards, or those defined internally as being directly relevant to target market/customer requirements); and
- Are manufactured efficiently in terms of production cost per tonne.

The process control system defined in this document targets these same aims.

Note that this ROU system has been developed with direct participation of experienced *ISO 9001 Quality Management System (QMS)* and *AS4454* auditors, and represents a simple and practical process control system that is consistent with the requirements of an *ISO 9001 QMS* for compost operations.

However, whilst the process control system defined here is consistent with, and can underpin an ISO 9001 QMS, the requirements for an ISO 9001 compliant and/or accredited QMS are significantly more detailed, require a larger range of procedures and forms, and are significantly more expensive to develop, implement and maintain. Additionally, documentation of such procedures requires incorporation of aspects of an operation that are specific to the individual organisation, site, infrastructure, commercial and regulatory context.

The specific process control system defined here provides a starting point towards an ISO 9001 compliant and/or accredited QMS, and represents a significant step towards consistent achievement of customer satisfaction, and management of commercial risk.

The ROU has developed an *ISO 9001 QMS Template Package for Compost Facilities* that minimises cost and accelerates the timeframe for QMS implementation, and provides this service on a commercial basis to facilities.

1.5 Product certification and ISO 9001 QMS

Product quality literally refers to product that is suitable for the intended purpose. This is assessed via conformance to specifications.

The issue is not simply whether the current batch of product complies with specifications. The issue is whether the company can be relied upon to consistently manufacture to documented specifications and standards.

For product to be independently certified for compliance with the Australian Standard AS4454 or the Compost Australia LeafMark scheme, the compost manufacturing company is required in the first instance to operate under an independently certified AS9001 Quality Management System.

Certification evidences that both the production system AND the specific product are independently audited and assessed for ongoing compliance.

Lastly, AS4454 states: manufacturers making a statement of compliance with this standard must ensure that such compliance is capable of being verified. This requires test reports of representative product samples AND relevant production records – such as those detailed in this guide.

2 Composting principles

2.1 Composting – what’s that?

Composting is the biological transformation of organic materials. Aerobic composting, if well monitored and managed:

- Produces sufficient heat (thermophilic temperatures) in the composting mass to pasteurise (sanitise) the organic materials, destroying weeds and seeds, and killing plant and human pathogens that may be present in the raw materials;
- Can consistently produce a sufficiently mature compost product of desirable chemical, physical and biological properties in a consistent time frame, with known and cost effective application of effort and management intervention.

2.2 Compost science - inside the compost pile

A basic understanding of the processes inside the composting pile as relevant to commercial compost production are documented in Recycled Organics Unit (2001c) *Composting Science for Industry* and other ROU packages. A brief overview of the relevant fundamentals is provided here, as an essential introduction to the factors that directly effect the composting process is essential to monitoring and decision making for effective and efficient management of the compost pile.

What goes on inside the aerobic compost pile:

- Aerobic refers here to an environment where access to air (or oxygen) is not limited. In the composting process this supports thriving populations of suitable soil microorganisms commonly found in friable, moist topsoil beneath a layer of mulch.
- An aerobic compost pile is a mass of suitable food, with sufficient moisture and air as required to support an active microbiological population of primarily bacteria, protozoa and fungi.
- These microorganisms consume the compostable materials, requiring both sufficient air and moisture to do so. The early stages of the composting cycle are characterised by very rapid population growth and frenetic biological activity as the microorganisms consume simple compounds such as sugars, in the process generating heat and CO₂.
- Peak oxygen demand occurs during these early stages of the composting cycle, as does the generation of heat and CO₂.
- The temperature generated by this biological activity is sufficient to pasteurise the materials, and to destroy weeds, seeds, and pathogens (human and plant disease organisms).
- In a compost pile of sufficient size, the rate of temperature generation is greater than temperature loss to atmosphere as the outer layer insulates the interior of the pile, allowing temperatures to build up in the centre.

- Turning of the pile is required to ensure all materials spend sufficient time in the hot centre of the pile for all materials to be pasteurised.
- Where moisture, oxygen or food value are insufficient biological activity is limited or reduced, and temperatures decline.
- When the readily consumed simpler compounds have been consumed (assuming sufficient air and moisture), biological activity as measured by temperature, oxygen consumption or CO₂ respiration is reduced. This is the onset of biological stability, and progress towards compost maturity.
- As temperatures decline (assuming sufficient air and moisture) the biological community changes, with increased population of fungi that require lower temperatures and consume some of the more resilient woody compounds such as lignin.

2.3 Critical monitoring and management of the compost pile

This basic understanding of the composting process and cycle identifies moisture, air and temperature, turning, and available food as the five critical factors for monitoring and management of the compost pile.

2.3.1 Moisture:

- Moisture content of 35 – 55% is required for hot aerobic composting. Commercial scale compost producers in warm temperate Australia generally shred and mix together materials that will have a moisture content of ~ 50 – 55% when combined, with the aim of the moisture content reducing to a moisture content of around 40% when the composting is released for sale (via evaporation and turning).
- In summer months additional moisture may be added using sprinklers placed on the top of trapezoidal shaped windrows.
- The shape of a compost pile influences absorption of water. A flat or concave topped compost windrow will catch rain/irrigation and better allow it to soak in where windrows are dry, whereas a triangular or peaked shape will better shed water during periods of high rainfall.
- Compost piles can be turned to mix in moisture, or to aid in drying out.
- A moisture content of 40% or just below is generally ideal for screening compost into grades (particle size).
- At moisture contents below 30 – 35%, moisture becomes limiting, and microbial activity is inhibited.
- At moisture levels below ~ 30%, compost begins to become dusty and there is inadequate moisture to support significant levels of biological activity.

Key points for compost management:

- Moisture content of 35 – 55% is required for hot aerobic composting.
- The process for field assessment of windrow moisture using the "squeeze" or "fist" test is documented in Appendix B.

2.3.2 Aeration and temperature:

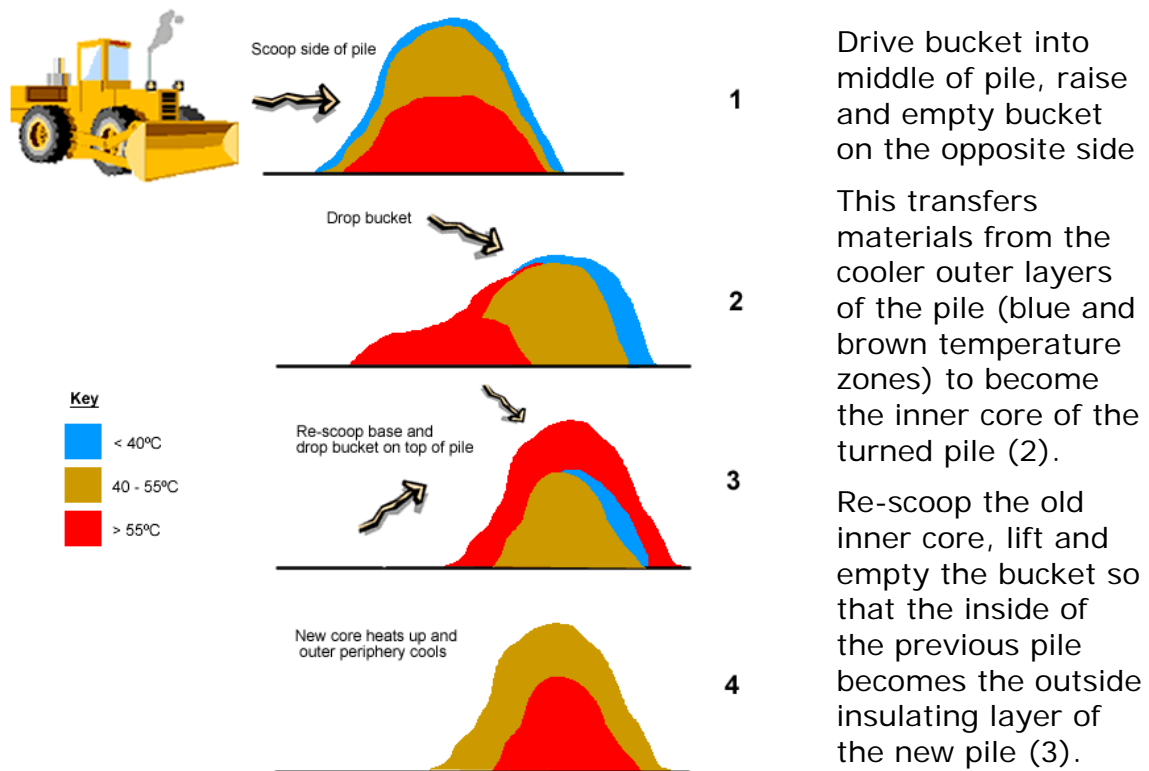
- Air contains 21% oxygen, which is required for the biological function of the beneficial aerobic microorganisms that are responsible for composting.
- Where oxygen is limiting, biological decomposition is slowed, temperature generation is limited, and effective pasteurisation of materials will not be achieved. Additionally, insufficient air supports the proliferation of anaerobic organisms that produce obnoxious odours and potent greenhouse gases.
- Commercial scale compost producers generally shred and mix together materials that have porosity and structure for sufficient air to enter the pile through convection and diffusion to maintain an aerobic biological process.
- This requires the periodic turning of compost piles to introduce air (oxygen) into the compost mass, and to reduce the density of the pile thereby increasing the porosity and movement of air into the pile.
- Recommendations on maximum pile size are widely available, however pile size and rate of oxygen consumption should be considered within the context of the raw materials being processed, and both the type and availability of machinery for turning piles. Generally piles with putrescible materials or less coarse woody material for structure will require smaller cross sectional area.
- Turning is usually required more frequently in the initial stages of rapid decomposition where prolific biological activity requires more air (oxygen), and less frequently as decomposition slows approaching compost maturity.
- Although oxygen can be measured with a windrow probe, these are relatively expensive, and temperature is more commonly measured as an indicator using a heavy duty compost thermometer. Provided moisture content is suitable, declining temperature is an indicator of reduced biological activity due to either inadequate air or maturing compost. In the early stages of composting, this indicates aeration (oxygen level) is inadequate and is limiting biological activity, and signals a requirement for turning the compost pile. This is commonly referred to as temperature based turning.
- Temperatures of 55 °C or greater for a period of 3 consecutive days is required to achieve pasteurisation of materials. Pasteurisation destroys weeds (plant materials), weed seeds, and both human and plant pathogens (disease organisms) that may present in the raw materials.
- As the outer layers are cooler than the inner layers, this requires that windrows are turned to ensure that all materials spend sufficient time in the hot centre of the pile (see *Section 2.3.3 Turning compost piles* below).
- Monitoring of temperature is critical to identify when oxygen has become limiting and turning is required for aeration, and to confirm and document that pasteurisation is achieved.
- If piles remain unturned when oxygen becomes limiting, the centre of a turned windrow may become anaerobic as oxygen entering the outer layers of the pile is consumed by microorganisms before can reach the centre. Anaerobic conditions will result in the generation of obnoxious odours and potentially of potent greenhouse gases. Turning such piles will release problematic odours.

2.3.3 Turning compost piles:

The aims of turning are:

- To lift and loosen the compost materials, such that the turned pile has lower density and supports increased air penetration via convection and diffusion.
- To break up clumps, mix materials and distribute moisture evenly through the pile.
- To ensure all materials spend time in the hot centre of the pile.
- To avoid damage to the compost pad (composting surface) and mixing of inorganic materials from the pad into the compost product.

Procedure for turning a pile with a front-end loader to ensure that all materials are exposed to pasteurising conditions in the hot centre of the pile:



This step places materials from the hotter inner regions (red temperature zone, >55°C) of the previous pile to the outside to act as an insulating blanket to assist in the build-up of temperatures of the new core. After a day or so, the new core will heat up to pasteurising temperature, whilst the outer layer cools.

Driving the loader with the bucket toe/tip tilted slightly upwards reduces risk of damage to the compost pad, and avoids contamination of compost product with inorganic materials from the pad (ie. stones).

2.3.4 Food and energy value:

- The raw materials from which a compost pile is formed are a complex mix of organic compounds ranging from simple sugars and starches to more complex and resistant molecules such as lignocellulose and lignin.

- In general terms, composting microbes first consume compounds that are more easily consumed or more 'susceptible' to degradation in preference to compounds that are more resistant.
- The breakdown of organic matter is therefore a step-wise reduction of complex substances to more simple compounds.
- During the initial, intensive phase of composting, the more easily degradable compounds are broken down first (sugars, starches, fatty acids, amino acids, proteins).
- The initial period of composting is characterised by rapid increase in microbial activity and generation of high temperature (up to ~ 70°C).
- Once these compounds are exhausted, microbial activity and temperature declines. The lower temperatures (<45°C) are suitable for the growth of fungi and actinomycetes that are largely responsible for consuming compounds that are more difficult to break down, such as lignocellulose and lignin.
- As composting proceeds, the amount of organic food material available to microorganisms reduces, with reduced biological activity resulting in reduced heat production and reduced peak compost pile temperatures after turning.
- Provided oxygen and moisture are not limiting, monitoring the trend of peak temperature achieved after turning provides an indicator of compost maturity.
- Standardising process monitoring and management, with regular turning as required should result in a relatively reliable time frame for the production of suitably mature compost. For confirmation of maturity see Section 4 below.

Key points for compost management

Temperature of the compost pile must be monitored

- to identify if the temperature is sufficiently hot to pasteurise materials,
- to verify and record that pasteurisation has been achieved for the purpose of compost quality and management of commercial risk,
- to identify whether core temperature is increasing or decreasing, with decreasing temperature (assuming suitable moisture) indicating either:
 - a) that air has become limiting and compost pile requires turning; or
 - b) that biological activity is decreasing due to reduced food value in the pile.

In a suitably moist compost pile, where peak temperature achieved after turning declines, this indicates the transition from the initial primary stabilisation phase of the compost cycle, and temperature trend in combination with other attributes can be used to indicate compost maturity.

- The process for assessment of temperature using a heavy duty compost windrow thermometer is documented in Appendix B.
- The *Compost batch tracking form* for recording temperature and other windrow data is provided as Appendix A

3 The compost pile Process Control System

This section provides document templates and specifies their systematic use, in conjunction with the defined on-site monitoring procedures for tracking each compost pile through the production process for monitoring, informed management, quality control, and authorised release of the compost pile when suitable for sale.

Note that this process control system has been developed in direct consultation with experienced *ISO9001 QMS* and *AS4454* auditors from Standards Australia / SAI Global. It results a decade of experience of the ROU, and represents the simplest practical system for this purpose that is both functional, and is also consistent with the requirements of an *ISO9001 QMS*. This system can be retained should your organisation choose to pursue product certification under published product standards such as *AS4454 (2003)*, or *ISO 9001 QMS* certification.

This process control system includes the following components:

- Compost batch tracking form
- Windrow composting tag
- Windrow released tag

This system described here operates like the “farm gate rule”, the roles and responsibilities are clearly defined, each role incorporates a simple requirement for recording of action undertaken at the time, avoiding unnecessary duplication of effort or confusion as to what tasks have been completed. The result is a complete record of management for each compost batch, and evidence of pasteurisation and sufficient maturity prior to release of the compost batch for sale.

Note that in QMS language, there are forms. Upon recording the relevant information on these forms, the completed forms then become “records”.

3.1 Windrow tag – windrow composting tag

Each individual compost windrow, or batch requires an identification number or code to enable the batch of compost to be tracked through the production system for monitoring and management, assessment and release for sale, for retention of relevant records both for the purpose of risk management and for process management via the identification of anomalies and/or trends.

The recommended approach for assigning batch numbers is to use the “date of birth” of the windrow (ie. date of windrow formation). It is preferable to use the international standard format (yyyy/mm/dd) as this format can be automatically sorted in chronological order in computer files and databases.

The *windrow composting tag* colour and heading clearly identifies that the windrow is an actively managed compost pile (ie. still “composting”, and NOT released for sale). Each *windrow tag* should be sufficiently large and

distinctly coloured to be recognised from a distance, and should be positioned so as to be clearly visible from the cabin of the loaders and windrow turners use at the facility. The date of each turning of the windrow must be marked on the *windrow composting tag*.

In relation to operational procedures, loader drivers tasked with turning the windrow must be responsible for the *windrow tag*. Procedures should require that the loader operator:

- Must remove the *windrow composting tag* prior to turning (to prevent burying);
- Must record the date of the turning event on the *windrow composting tag* (in the yyyy / mm / dd format); and
- Must replace the updated *windrow composting tag* in the appropriate (correct) location after turning of the windrow is complete.

Loader drivers are commonly reluctant to get down from the cab of a loader to fulfil this task, but experience has shown that assigning the responsibility to someone other than the loader driver responsible for turning the windrow commonly results in *windrow tags* being buried in the windrow and "lost" during turning operations.

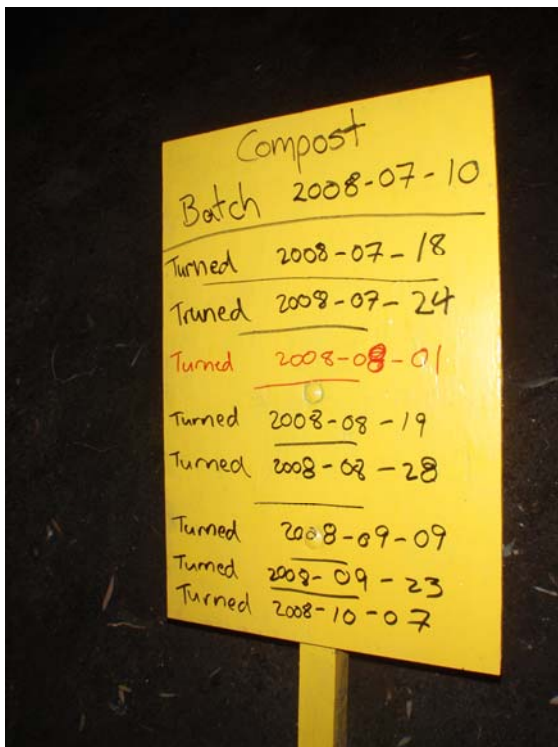
Each vehicle / loader driver should carry a chisel head permanent marker for marking the *windrow tags*. Idealised layout of the *windrow composting tag* is shown below, pictures of an actual tag follow on next page:

COMPOSTING BATCH No. (DOB)		
Turned:	yyyy	mm / dd
Turned:	/	/
Turned:	/	/
Turned:	/	/
Turned:	/	/
Turned:	/	/
Turned:	/	/
Turned:	/	/

Constructing *Windrow Tags*

The following recommendations are provided for constructing *Windrow tags*:

- Construct windrow tags from 12 – 15mm thick plywood (CF grade, waterproof glue, dressed on one side).
- A 400 x 600mm piece is sufficiently large for a single *windrow tag* for information to be clearly marked, and readily cuts from a standard 1200 x 2400mm sheet to provide 12 tags per sheet of ply. Alternatively 12mm recycled plastic board (Plaspanel) can be used¹.
- Bolt the ply to 900mm long 50mm square hardwood peg using 2 galvanised cup head bolts ~ 75 – 80mm length.
- Paint to cover ply and seal all gaps/penetrations with 2 or 3 coats of self priming exterior grade oil based paint, providing a smooth surface that markers will write on effectively (White Knight paving paint works well).
- Use chisel head permanent markers for recording turning dates etc.
- Once the batch is complete and released, use acetone to clean the marker from the tag for use on a new windrow.



¹ Same 2400 x 1200mm sheet size as for plywood, made from recycled Polyethylene and worked like timber
www.plaspanel.com.au

3.2 Compost batch tracking form

The **Compost batch tracking form** is provided as a template in *Appendix A* of this guide.

NOTE: in QMS language, there are “forms”. Upon recording the relevant information on these forms, the completed forms then become “records”. The **compost batch tracking form** therefore becomes the **batch record** once data is entered, and is retained on file to inform process improvements and for management of commercial risk.

Compost batch tracking form							Form No.	
Batch No. (date of birth)		Raw material receival period						
Date yrr/month/day	Turned yes/no	Temp °C			Moisture dry/ok/wet	Action required		
Eg: 2008/04/21	no	61	57	56	55	Wet, storms forecast	Form in peaked shape next turn	
1.								
2.								
3.								
4.								
5.								
6.								
7.								
8.								
9.								
10.								
11.								
12.								
Release date		Authorised by						
Test results (as measured on-site)								
Moisture	EC	pH	Solvita maturity	Ammonia NH3	CO2			
Comments/lab report number								

A staff member with suitable technical capability and methodical disposition should be assigned responsibility for windrow monitoring and record keeping. The role of this quality officer position is to support the production manger to make informed operational decisions. This position:

- OWNS and is directly responsible for maintaining the Batch Records,
- Transcribes turning dates from the *windrow tags* to the respective *compost batch tracking forms*,
- Measures windrow core temperatures and assesses moisture of compost piles as per schedule and in accordance with field monitoring procedures and records measurements on the respective *compost batch tracking forms*. Frequency of temperature and moisture monitoring will depend on windrow age and weather,

- Informs Production Manager of recommended actions required (or not required) for each windrow, and justifies recommendations as required with documented evidence via batch records,
- Documents additional field observations when and as relevant to indicate determining whether windrow is sufficiently mature for sampling and maturity testing,
- Collects and maintains representative samples from windrows for maturity assessment in accordance with documented procedures,
- Prepares samples and conducts Solvita maturity test in accordance with Solvita instructions. Documents Solvita results on the Solvita record sticker and affixes this to the back of the respective *compost batch tracking form*.
- Presents completed batch record to Production Manager for review and formal authorisation of release of windrow for sale (signature),
- Releases windrow by removing windrow composting tag and replacing with windrow released tag,
- Cleaning markings from windrow tags for reuse,
- Collects and prepares representative samples from windrows for laboratory analysis as directed and in accordance with documented procedures. Packages, labels and dispatches samples to preferred laboratory in accordance with documented procedures,
- Reviews laboratory results with Production Manager with reference to relevant *batch record*, and follows up with laboratory for clarification as required,
- Files *batch records* and associated laboratory results in specified manner and location.

Batch records must be retained for continuous improvement of operational processes, to inform efficient scheduling of production, to identify seasonal variation in compost production, for management of commercial risk, and to identify the actual cost of production.

3.3 Windrow tag – windrow released tag

Windrows must be assessed and a deliberate determination made as to when the compost is ready and suitable for sale (see Section 4 of this guide).

Once a windrow is “released” for sale, the windrow must be clearly marked as released in an unmistakable manner. Preferably the process of authorising and releasing a windrow/batch requires the designated person to take a deliberate and positive action.

The designated person authorising release of windrow must be responsible for

- Authorising release of the windrow for sale via signature on the relevant *Batch Record* form (after review of relevant results); and
- Removing the yellow *windrow composting tag*, and replacing it with a green *windrow released tag*.

Regardless of specific colours used, these windrow tags must be sufficiently large and distinctively coloured to be clearly recognised and distinguished from at a distance, and be positioned so as to be clearly visible from the cabin of the loaders/excavators/windrow turners in use at the facility.

Construct the *windrow released tag* using the same materials and process as for the *windrow composting tag* (see Section 3.1), but paint these *windrow released tag* in a clearly different colour. A single sheet of ply will provide 12 windrow tags.

<p>RELEASED Release date</p>
<p>Authorised</p>
<p>BATCH No. (DOB)</p>

4 When is compost mature & ready for sale?

A question asked by every compost producer at some point is:

When is a compost windrow ready for release and sale?

You can only realise a reliable answer to this question once you have instituted a process control system that delivers a reasonably consistent production process.

If we refer back to Section 1 of this guide, the first steps to compost product quality include:

- b) Define and document the primary target markets/applications for which compost products will be manufactured,
- c) Define and document the relevant specifications of each of these compost products (chemical, physical and biological characteristics);

Product specifications should include required maturity of the compost product for these target markets / applications. We will therefore assume this is known.

Where the process control system described has been implemented, we can assume that moisture levels of the compost piles have been maintained that are suitable for aerobic composting. We can also assume and that oxygen is not limiting as piles have been turned when indicated on the basis of temperature.

Where production processes are reasonably reliable, a combination of process and temperature records and direct observations can be applied to allow processing duration and peak temperature achieved after turning to indicate when a compost batch (windrow) is ready for sampling for direct assessment of maturity. Maturity can then be directly confirmed via on-site field test using the Solvita maturity test kit, enabling the compost to be released for sale.

The table below documents how each item can be applied to indicate maturity:

Item	Indicator	Implication
Raw materials	Consistent known source of raw materials	No significant introduced variables
Plant and equipment	Consistent use of same raw material shredders and windrow turners	No significant introduced variables
On-site process records / observations	Moisture records	Identifies that moisture has not limited the rate of composting
	Temperature and turning records (Appendix A Compost batch tracking form)	Evidences timely turning of windrows for aeration, and that aeration has not limited the rate of composting (relative to standard practice)
	Temperature and turning records	Provide evidence of pasteurisation for management of commercial risk

	Field observations	Absence of obnoxious odour and flies on surface of moist compost pile indicates aerobic processing and absence of putrescible materials (ie. have putrescible materials have been biologically transformed)
	Temperature records	Declining trend in peak temperature achieved after turning progressively indicates achievement of biological stability. Where observations and records above indicate consistent manufacturing process, peak temperature achieved after turning can be reasonably correlated to compost maturity.
	Compost process duration	Where observations and records above indicate consistent manufacturing process, composting duration can be reasonably correlated to compost maturity.
On site maturity batch testing	Solvita maturity test kit	One or more composite representative samples per compost batch (windrow) can be tested using the Solvita kit to: a) Confirm achievement of compost maturity level required for conformance with relevant internal specifications for release of windrow for sale b) Provide records that adequate compost maturity is achieved for commercial risk management
Commercial laboratory batch testing	Laboratory test for conformance with published standards (eg. AS 4454) and regulatory requirements	One or more composite representative samples of compost batches (windrow) can be periodically tested at accredited commercial laboratories to: a) Confirm that the maturity level indicated by on-site Solvita test for release of windrow for sale conforms to published standards b) Provide evidence of adequate maturity of compost for sale for management of commercial risk

There is a need to correlate composting duration and/or peak temperature achieved after turning with the Solvita test, particularly with regard to seasonal variation. This is a process of trial and error – a process that fundamentally relies on consistent production processes to deliver results.

Standardising process monitoring and management, with regular turning as required should result in a relatively reliable time frame for the production of suitably mature compost, and enables the reliance on observable indicators of the achievement of compost maturity prior to sampling and direct testing.

It should also be noted that this approach would apply to each particular stream of raw materials that are processed in a particular manner. Garden organics materials that are shredded and composted may require a significantly different processing duration compared to a compost pile formed from a combination of food waste, pig manure and sawdust to achieve the same specified level of maturity, and temperature trends and levels are also likely to be quite different. Similarly a different result may be achieved from the use of a windrow turner rather than a wheel loader on compost piles formed of the same material; similarly the use of a different shredder that size reduces raw materials to a different particle size grading prior to composting can introduce variables.

A documented procedure is required for your facility for: *Assessment of compost windrow maturity for release of compost batch for sale.*

This procedure may include other characteristics such as compost moisture level, pH and EC, and potentially nutrient content as relevant for determining suitable application rates.

The procedure should include assignment of responsibility to relevant staff and management positions, and retention/storage of batch records.

5 Implementation checklist from the Wingecarribee Resource Recovery Centre

5.1 Stepwise implementation checklist

The Wingecarribee Shire Council operates a Resource Recovery Centre (RRC) in Moss Vale, NSW. This integrated resource recovery facility, amongst other reuse and reprocessing activities, implements a regional organics recycling facility where wood waste, garden vegetation and other putrescible organic materials are processed into a range of recycled organic mulches and composts.

This section identifies the stepwise process and field testing tools in use at the facility, and the costs associated with implementation of the process control system described in this manual.

The process has involved the following steps:

- a. Formal management commitment to consistent production of quality recycled organics products via adoption of quality policy, and assignment of responsibility and resources for implementation.
- b. Construction of the windrow tags.
- c. Purchase of monitoring tools, including compost thermometer and Solvita maturity test kits.
- d. Assignment of roles to specified staff, integration into job descriptions, and integration of tasks into operational procedures.
- e. Half day hands on training for relevant staff into the correct implementation of associated procedures, including discussion and resolution of practical issues arising.
- f. Implementation of Process Control tracking system:
 - Windrow composting tags.
 - Monitoring and recording of windrow formation date, turning dates, temperature records, moisture for identifying required management interventions and to evidence achievement of pasteurisation.
 - Extracting representative sample from windrow and field assessment of compost maturity using Solvita maturity test kit.
 - Release of windrows for sale.
 - Extracting representative sample from windrow for dispatch to laboratory for testing for conformance with defined product specifications.
 - Maintaining batch records for management of commercial risk.
- g. Time/effort and expense per sample for commercial lab testing for conformance with AS4454.

5.2 Implementation costs

5.2.1 Compost windrow thermometer



Heavy duty compost windrow thermometer, stainless steel with “unbreakable” hermetically sealed crystal face for measuring temperatures inside a compost windrow or pile. Has a range of 0 to 100 degrees Celsius. Most common length is stem length is 91 cm (36”), other lengths available. **Ensure you specify Celsius**, as the standard models display in Fahrenheit.

Cost: ~\$150 US plus postage

Supplier: REOTEMP Instrument Corporation, USA

Internet: www.reotemp.com

5.2.2 Solvita Compost Maturity Kit



On-site colorimetric assessment of compost maturity via Carbon dioxide respiration. Provides rapid assessment of compost maturity; and evidence of achievement of adequate compost maturity for release of windrows for sale prior to screening and blending into value added products.

Solvita measures CO₂ respiration (indicator of biological activity) and ammonia NH₃ *volatization* (which can suppress biological activity, particularly relevant for manure composts) to provide rapid (4 hours) and reliable results on the degree of maturity of compost-based products.

Cost:

- 24 test pack (item 2265) *Solvita Compost Master Kit* \$275 US plus post
- 6 test pack (item 2261) *Solvita Compost Maturity test* \$95 US plus post
- NOTE: kit has shelf life, store correctly and use all kits within 12 months

Supplier: Solvita - Woods End Research Laboratory

Internet: www.solvita.com

5.2.3 Laboratory testing for compliance with product standards

The primary published standard for composts (both soil conditioner and mulch grades) is the Australian Standard *AS4454 Composts, soil conditioners and mulches*. NATA accredited commercial laboratories require a 10 litre representative sample of compost product for comprehensive assessment of conformance with the specifications documented in the standard.

At minimal additional charge these laboratories will provide a brief interpretation report and recommendations. Such laboratories can test for other attributes upon request that may be relevant to your particular product specification, ensure you specify the preferred units for reporting of results.

Refer to appendices B and C of this document for sampling and shipping procedures. In brief, the ~ 10 litre representative sample should be packed in a bucket with sealed lid, labelled with laboratory delivery address/contact number/person, and clearly marked: **kept in cool location out of direct sunlight**. If possible, ship sample in morning via courier for same day delivery. Place your request for services letter inside the bucket in a sealed ziplock plastic bag – specify your **compost batch identification code** for inclusion on the results sheet / interpretation report (date of birth from windrow composting tag – see section 3.5 of this report).

Cost (April 2009):

- \$450 per batch, this includes batch handling fee and testing for pesticides and heavy metals as specified in NSW biosolids guidelines.
- Additional \$20 for recommendations for rectification of non-conformances
- Testing for pathogens as per NSW biosolids guidelines is additional \$120.

Supplier:

A list of commercial laboratories is detailed at providing www.recycledorganics.com follow the "Laboratory Services" link on the left hand side of page. Results should be available within 2 weeks of receipt of sample by laboratory.

5.2.4 Additional on-site laboratory equipment

Additional equipment such as sieves for separating into particle size grades, a precision balance and drying oven, pH and EC meters and associated calibration solutions will provide greater on-site compost product testing capability, and potentially require less frequent external laboratory testing.

Laboratory grade equipment is expensive, and is justified only for the purchase of a precision balance with an accuracy of 0.01 g, such precision balances will have a maximum weight of < 2.5kg and are available for ~ \$1,000. Google "precision balance" and "Sydney" to find a supplier.

6 References

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- NSW Department of Environment and Climate Change (2008d) *Current General Residue Waste Exemptions under the POEO (Waste) Regulation 2005*. Internet publication <http://www.environment.nsw.gov.au/waste/residue/genexempts.htm>

7 Appendices

Appendix A: Compost batch tracking form

- The use and role of the *Compost batch tracking form* is described in Section 3.2 of this report.

Insert your company logo / details here.

NOTE: in QMS language, there are "forms". Upon recording the relevant information on these forms, the completed forms then become "records". The **compost batch tracking form** becomes **batch record** once data is entered.

Compost batch tracking form

Form No.

Batch No. (date of birth)		Raw material receival period					
Date yr/month/day	Turned yes/no	Temp °C				Moisture dry/ok/wet	Action required
Eg: 2008/04/21	no	61	57	56	55	Wet, storms forecast	Form in peaked shape next turn
1.							
2.							
3.							
4.							
5.							
6.							
7.							
8.							
9.							
10.							
11.							
12.							

Release date		Authorised by	
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Test results (as measured on-site)					
Moisture	EC	pH	Solvita maturity	Ammonia NH3	CO2
Comments/lab report number					

Refer to procedures: *compost windrow management* and *compost windrow release for sale* in: Recycled Organics Unit (2008) *Practical Process Control for Consistent Production of Quality Compost*. Recycled organics Unit, internet publication: www.recycledorganics.com

Appendix B

ROU Information Sheet 3.3: On site field testing and monitoring for quality

This information sheet from the ROU (2001) *Producing Quality Composts* information package provides stepwise procedures and pictures for the following processes:

- On site procedures for monitoring temperature, moisture, and oxygen as relevant to monitoring the compost piles for commercial risk management (evidence of pasteurisation), for compost pile management for consistent production, and for recording on the *Batch Record Form* documented in this practical process control manual;
- Procedures for taking representative samples from the compost pile and for on-site testing of maturity (Solvita/toxicity/EC/pH) as relevant to assessment and release of compost windrows as suitable for sale, and to inform product application guidance to be provided to customers;
- Procedures for taking representative samples from the compost pile for laboratory testing for chemical/physical/biological properties relevant to assessing conformance to either published compost quality standards, regulatory requirements, or product specifications defined by your organisation to meet identified market/customer requirements.

The complete *Producing Quality Composts* package is freely available on-line:

Recycled Organics Unit (2001) 3rd Edn. *Producing Quality Composts*. Recycled Organics Unit, internet publication: www.recycledorganics.com

Appendix C

ROU Information Sheet 3.11: Sample Management for Consistent Analysis of Product Quality

This information sheet from the ROU (2001) *Producing Quality Composts* information package for industry defines preferred requirements for handling, packaging, shipping and storing compost samples both for your organisation and for the commercial laboratory that conducts laboratory analysis of your composts to assess conformance with product standards.

Compost is biologically active, and characteristics of your sample will continue to change over time unless stored correctly. Whilst some commercial laboratories are highly experienced and can be relied upon to handle and store samples correctly, you should inform your preferred laboratory of your handling requirements and seek their agreement to manage samples in a manner consistent with these protocols.

The complete *Producing Quality Composts* package is freely available on-line:

Recycled Organics Unit (2001) 3rd Edn. *Producing Quality Composts*. Recycled Organics Unit, internet publication: www.recycledorganics.com

Appendix D

Overview: *Producing Quality Composts* package online

The updated third Edition of the *Producing Quality Compost* information package is freely available on-line and comprises a series of eleven easy-to-read information sheets.

This package is a practical guide to assist compost manufacturers to produce quality composts and value added products containing recycled organics. The guide has been written and produced to assist the composting industry manufacture quality products with a view to realising better returns and consumer satisfaction from their products.

The package *Producing Quality Compost* consists of eleven easy-to-read Information Sheets.

Download individual information sheets from the package as required

Recycled Organics Unit (2001) 3rd Edn. *Producing Quality Composts*. Recycled Organics Unit, internet publication: www.recycledorganics.com :

- Preface, Introduction and TOC to *Producing Quality Compost*
- Information Sheet 3-1: Striving for quality: basics of a quality management system
- Information Sheet 3-2: Quality assurance systems
- Information Sheet 3-3: On-site field testing and monitoring for quality
- Information Sheet 3-4: On-site laboratory testing for quality
- Information Sheet 3-5: Commercial laboratory testing for quality: recommended tests and how to select an independent laboratory
- Information Sheet 3-6: Quality of biosolids: risk minimisation during reprocessing
- Information Sheet 3-7: Manufacturing quality products: introduction to Australian Standard AS/NZ 4422-1996 for playground surfacing
- Information Sheet 3-8: Producing quality compost: introduction to Australian Standard AS 4454-2002 composts, soil conditioners and mulches
- Information Sheet 3-9: Manufacturing quality products from compost: introduction to Australian Standard AS 3743-2002 for potting mixes
- Information Sheet 3-10: Manufacturing quality products from compost: introduction to Australian Standard AS 4419-2002 soils for landscaping and garden use
- Information Sheet 3-11: Sample management for consistent analysis of product quality

Appendix E

Overview: *Composting Science for Industry* package online

The updated third Edition of the *Composting Science for Industry* information package is freely available on-line and comprises a series of eleven easy-to-read information sheets.

This package aids in understanding the fundamentals of composting and enables operators to manipulate the process to maximise the rate of decomposition of the organic material and meet other environmental or quality specifications.

The package *Composting Science for Industry* consists of nine Information Sheets. Download individual information sheets from the package as required.

Recycled Organics Unit (2001) 3rd Edn. *Composting Science for Industry*.
Recycled Organics Unit, internet publication: www.recycledorganics.com :

- Preface, Introduction and TOC to *Composting Science for Industry*
- Information Sheet No. 5-1: *Composting science for industry*
- Information Sheet No. 5-2: *Composting systems*
- Information Sheet No. 5-3: *Temperature*
- Information Sheet No. 5-4: *Oxygen*
- Information Sheet No. 5-5: *Water*
- Information Sheet No. 5-6: *Porosity, structure, texture and particle size*
- Information Sheet No. 5-7: *Carbon to nitrogen ratio (C:N) and other nutrients*
- Information Sheet No. 5-8: *pH*
- Information Sheet No. 5-9: *The composting recipe, processing time and curing*