A Procedure of Compiling an ISO Conforming Parts Library Dictionary

Saburo Tanatsugu†, Mamoru Kawanobe††, Isao Shirakawa†, and Hiroshi Ninomiya†

†Graduate School of Applied Informatics, University of Hyogo, Chuo-ku, Kobe, 650-0044 Japan.
††Benic Solution Corp., Chuo-ku, Kobe, 650-0038 Japan

Summary
This paper devises an ISO 13584-compliant procedure of compiling a 'parts library dictionary', the so-called *PLIB dictionary*, dedicatedly for a mechanical element of 'Chains'. This compiling procedure is composed of the following four steps of (1) creating a standardized identification hierarchy of chains by structuring chain families, (2) organizing all the necessary information on families and properties into three Excel Sheets, (3) mapping the entries in the Excel Sheets to instances of EXPRESS speci-fication, and (4) transforming these instances to a STEP physical file. A distinctive feature of this procedure consists in auto-matizing the process of the above steps (3) and (4) of mapping the entries in the Excel Sheets onto instances of the EXPRESS specification and then transforming them to a STEP physical file.

Key words:
Dictionary compilation, ISO 13584-compliant implementation, Mechanical element of chains, Parts library dictionary.

1. Introduction

WTO (World Trade Organization) insists that according to the agreement on TBT (Technical Barriers to Trade), Central Government Bodies of every ratifier should enforce technical regulations on the basis of international standards. This implies that the standards drafted by ISO (International Organization for Standardization) and IEC (International Electrotechnical Commission) should be preferentially enforceable not only for product databases but also for international trade and procurement.

The work of preparing international standards for product databases is now in execution through ISO technical working group TC184/SC4/WG2, where as a fundamental step of standardizing product databases, the compilation of 'parts library dictionaries' conforming to ISO13584-42 [1], i.e. '*PLIB dictionaries*', has been progressing in several countries.

In fact, an ECALS dictionary on 'electronic parts' [2] and an ISO 13584-501 reference dictionary on 'measuring instruments' [3] have been completed by JEITA (Japan Electronics and Information Technology Industries Association) and JEMIMA (Japan Electric Measuring Instruments Manufacturers' Association), respectively; while the actual work of compiling PLIB dictionaries of mechanical elements of 'fasteners' and 'cutting tools', is approaching completion in China and Sweden under ISO 13584-511 and ISO 13399-100, respectively.

However, in the real ISO-compliant implementation of a PLIB dictionary a tremendous amount of regulative rules should be rigorously enforced, which incur a great waste of time and labor, and hence an automatic scheme should be introduced into the compiling process, on which little attempt has ever been made.

The present paper devises a sophisticated procedure of compiling a PLIB dictionary dedicatedly for a mechanical element of 'Chains' by conducting the following steps of

(1) creating a standardized identification hierarchy by structuring chain families, according to ISO 13584-42 [1],
(2) organizing all the key information on families and properties into three Excel Sheets,
(3) mapping the entries in the Excel Sheets onto instances of the EXPRESS specification, in accordance with ISO 10303-11[4], and
(4) transforming these instances to a STEP physical file, as prescribed in ISO 10303-21[5].

A distinctive feature of this procedure consists not only in the above steps (1) and (2) of organizing the necessary information on structured families and properties of chains into three Excel Sheets, but also in automatizing the whole process of the above steps (3) and (4) of mapping the entries in the Excel Sheets onto instances of the EXPRESS specification to attain the final STEP physical file.

2. Standardized Hierarchy of Chains

ISO 13584-42 [1] specifies a standardized identification hierarchy of mechanical parts. The first step of our procedure is to create such a hierarchical family classification of a mechanical element of 'Chains'.

For this purpose, first enumerate all the classes and properties of 'Chains' dealt with in ISO standards. Tables 1 and 2 show the lists of such classes and properties, respectively. Here it should be noticed that as to class C of 'Motorcycle chains' in Table 1, there is another class of 'Drive chains' which has the same set of properties as 'Motorcycle chains', but has a different field of appli-

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cations. Henceforth, let part C be divided into two classes of C1 (Drive chains) and C2 (Motorcycle chains).

Table 1: List of classes of chains dealt with in ISO

A: Chains, sprockets and accessories-list of equivalent terms [6]
B: Flat-top chains and associated chain wheels for conveyors [7]
C: Motorcycle chains [8]
D: Bicycles chains [9]
E: Heavy duty cranked-link transmission chains [10]
F: Conveyor chains, attachments and sprockets [11]
G: Short-pitch transmission precision roller and bush chains, and attachments and associated chain sprockets [12]
H: Double-pitch precision roller chains and sprockets for transmission and conveyors [13]
I: Welded steel type cranked link drag chains and chain sprockets [14]
J: Steel roller chains, types S and C, attachments and sprockets [15]

Table 2: List of properties of chains dealt with in ISO

No.	Name of property
1	Chain Number
2	Pitch
3	Maximum bearing pin body diameter
4	Maximum width over bearing pins
5	Maximum roller diameter (small)
6	Minimum width between inner plates
7	Minimum bush bore
8	(Maximum width over bearing pins) / 2 + (Maximum additional width for joint fastener)
9	Maximum width over inner link
10	Minimum width between outer plates
11	Maximum inner plate depth
12	Maximum outer or intermediate plate depth
13	Transverse pitch
14	Plate width
15	Minimum cranked link dimension L1
16	Minimum cranked link dimension L2
17	Maximum plate depth
18	Maximum roller diameter (large)
19	Width over attachment
20	Maximum additional width for joint fastener

Now, in order to create a standardized hierarchy of 'Chains' by structuring chain families on the basis of ISO 13584-42[1], define a matrix of Table 3 such that

(i) each row and each column correspond distinctly to a property of Table 2 and a class of Table 1, respectively, and

(ii) the (i,j)-entry is '○' if and only if property i is essential to class j, in accordance with ISO standards [6-15].

Here it should be added that the whole class A of 'Chains' in Table 1 is omitted from Table 3, since if the column corresponding to class A were added to Table 3, then this column would have ○'s in all rows, which is redundant.

Table 3: Matrix of properties vs. classes

	B	C1	C2	D	E	F	G	H	I	J
1	○	○	○	○	○	○	○	○	○	○
2	○	○	○	○	○	○	○	○	○	○
3	○	○	○	○	○	○	○	○	○	○
4	○	○	○	○	○	○	○	○	○	○
5		○	○	○	○	○	○	○	○	○
6		○	○	○	○	○	○	○	○	○
7		○	○	○	○	○	○	○	○	○
8		○	○	○	○	○	○	○	○	○
9		○	○	○	○	○	○	○	○	○
10		○	○	○	○	○	○	○	○	○
11		○	○	○	○					
12		○	○	○	○					
13		○	○	○	○					
14		○	○	○	○			△		
15					○					
16					○					
17	○					○		○		
18						○		○		
19	○									
20				○						

(△ indicates that property 14 is used only for type A of double-pitch roller chain.)

Using this matrix of Table 3, an ISO conforming hierarchy is created by defining families and then structuring these families, as follows.

① Rows 1 through 4 have ○'s in all columns, and define a set X={B,C1,C2,D,E,F,G,H,I,J} of all classes corresponding to the columns of Table 3. In this case, X is a maximal set such that each class in X has the same set of properties 1 through 4, and hence set X constitutes a family of chains according to the rules [1]. Since this X is the same as the whole class A of 'Chains' in Table 1, henceforth let X be designated as a family of 'Chains'.

② Rows 5 through 10 have ○'s in columns of C1,C2, D,E,F,G,H,I, and J, and define Y={C1,C2,D,E,F,G,H, I,J}. In this case, Y is a maximal set of classes such that each in Y has the same set of properties 5 through 10, and hence set Y constitutes a family of chains. Henceforth, let this family Y be denoted by 'Roller & Bush chains'.

③ Rows 11 though 14 have ○'s in columns of C1,C2,D, and E, and define Z={C1,C2,D,E}. In this case, Z is a maximal set of classes such that each in Z has the same set of properties 11 through 14, and hence set Z constitutes a family of chains. Henceforth, let family Z be referred to as 'Transmission chains'.

Using the set inclusion relations of X=Y∪{B}, Y=Z∪{F,G,H,I,J}, and Z={C1,C2,D,E}, the standardized identification hierarchy of chain families can be drawn as illustrated in Fig. 1. To see how to construct this hierarchy, for example, consider a set inclusion relation of X=Y∪{B}. Associated with this relation, there corresponds the ancestry relation of vertices such that vertex X is the parent of vertices Y and B.

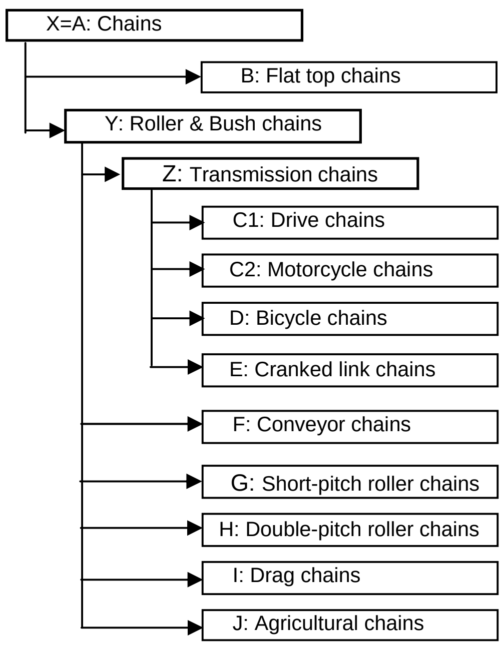

Fig. 1 ISO 13584 conforming classification of chains

According to ISO 13584-42 [1], each family corresponding to a *leaf* (i.e. a vertex which has no child) is referred to as a *simple family* of chains, and each family corresponding to a *non-leaf* (a vertex which has a child) is designated as a *generic family* of chains. Thus, a simple family indicates a family by itself which does not include any other family, and a generic family of chains consists of simple and/or generic families of chains.

3. Construction of Excel Sheets

Now, we will assign the BSU (Basic Semantic Unit) codes to families of Fig. 1 and properties of Table 2, which are key elements for the EXPRESS specification as well as for the STEP physical file.

Before conducting this work, we have to take account of the fact that in the actual work of compiling PLIB dictionaries of 'fasteners' and 'cutting tools', now conducted in China and Sweden, respectively, the EXPRESS specifications and STEP physical files are constructed precisely in accordance with ISO 13584-42 [1], ISO 10303-11[4], and ISO 10303-21[5], where a great amount of regulative rules and operations have to be enforced rigorously, and hence only a limited number of highly qualified professionals can take part in the practice of the compilation.

Thus, in order to make the compilation process be applied widely to other mechanical elements, the present paper attempts to automatize the process of constructing an EXPRESS specification and transforming it to a STEP physical file as follows.

[Phase I] On the basis of the hierarchy, let all the key information of families and properties, including BSU codes assigned to them, be organized into three Excel Sheets.
[Phase II] By means of a mapping scheme developed originally by the authors in accordance with the rules prescribed in ISO 10303-11 [4], map the entries in the Excel Sheets onto instances of the EXPRESS specification.
[Phase III] Transform these instances to a STEP physical file according to ISO 10303-21 [5].

In what follows, three Excel Sheets stated in **[Phase I]** are constructed.

3.1 Family Sheet

According to the family hierarchy of Fig. 1, assign BSU codes to all families of chains, and then let these BSU codes be written into the Family Sheet as shown in Table 4. It can be seen from this Sheet that

(i) the columns of CODE, PARENT, and PREFNAME. EN contain the BSU codes of families, those of their parents, and family names expressed in English, respectively, and
(ii) row i corresponds to the family specified by the entry at (row i, column PREFNAME.EN), the entry at (row i, column CODE) indicates the BSU code of the family at row i, and the entry at (row i, column PAREMT) represents the BSU code of the parent of the family at row i.

Here, it is added that this Sheet should involve a number of columns, such as PREFNAME.JP, PREFNAME.CH, etc., which are to contain family names expressed in Japanese, Chinese, etc., respectively, but any of them is omitted here due to limited space.

Table 4: Family Sheet

PARENT	CODE	PREFNAME.EN
$ROOT$	UOH001	Chains
UOH001	UOH002	Flat top chains
UOH001	UOH003	Roller & Bush chains
UOH003	UOH004	Transmission chains
UOH004	UOH005	Drive chains
UOH004	UOH006	Motor cycle chains
UOH004	UOH007	Bicycle chains
UOH004	UOH008	Cranked link chains
UOH003	UOH009	Conveyer chains
UOH003	UOH010	Short pitch roller chains
UOH003	UOH011	Double pitch roller chains
UOH003	UOH012	Drag chains
UOH003	UOH013	Agricultural chains

3.2 Property Sheet

Assign a BSU code to each property of Table 2 according to ISO 13584-42 [1], and then let these BSU codes be written into the Property Sheet as shown in Table 5. It can be seen from this Sheet that

(i) the columns of FAMILY.BSU, CODE, and PREF NANE contain BSU codes of families, BSU codes of properties, and property names expressed in English, respectively,

(ii) row i corresponds to the property specified by the entry at (row i, column PREFNAME.EN), and the entry at (row i, column CODE) indicates the BSU code of the property at row i, and

(iii) entry at (row i, column FAMILY.BSU) denotes the BSU code of the lowest common ancestor of those families for which the property at row i is used.

Here, it should be added that this Sheet should involve a number of columns, such as PREFNAME.JP, PREFNAME.CH, etc., which are to contain property names expressed in Japanese, Chinese, etc., respectively, but any of them is omitted here due to limited space.

To see how to construct this Sheet, for example, consider property 14 of Table 2, which is used for classes C1, C2, D, and E of generic family Z as well as for class H of simple family, as can be seen from Table 3. Since in Fig. 1 vertex Y is the parent of vertices Z and H, family Y is the lowest common ancestor of families Z and H. Hence, due to (iii), property 14 (UOHP014) is defined at family Y (UOH003), that is, the entry at (row 14=UOHP014, FAMILY BSU) is UOH003 (Y).

3.3 Property Applicability Sheet

Let the applicability of properties to families be written into the Property Applicability Sheet as shown in Table 6.

Table 5 Property Sheet

FAMILY. BSU	CODE	PREFNAME.EN
UOH001	UOHP001	Chain Number
UOH001	UOHP002	Pitch
UOH001	UOHP003	Maximum bearing pin body diameter
UOH001	UOHP004	Maximum width over bearing pins
UOH003	UOHP005	Maximum roller diameter(small)
UOH003	UOHP006	Minimum width between inner plates
UOH003	UOHP007	Minimum bush bore
UOH003	UOHP008	(Maximum width over bearing pins)/2 + (Maximum additional width for joint fastener)
UOH003	UOHP009	Maximum width over inner link
UOH003	UOHP010	Minimum width between outer plates
UOH004	UOHP011	Maximum inner plate depth
UOH004	UOHP012	Maximum outer or intermediate plate depth
UOH004	UOHP013	Transverse pitch
UOH003	UOHP014	Plate width
UOH008	UOHP015	Minimum cranked link dimension L1
UOH008	UOHP016	Minimum cranked link dimension L2
UOH001	UOHP017	Maximum plate depth
UOH003	UOHP018	Maximum roller diameter(large)
UOH002	UOHP019	Width over attachment
UOH007	UOHP020	Maximum additional width for joint fastener

It can be seen from this Sheet that

(i) the columns of FAMILY.BSU and PROPERTY. BSU contain BSU codes of families and properties, respectively,

(ii) if a generic family F with BSU code B(F) is defined such that each in F has the same set P of properties, then for each property p of P with BSU code B(p), the row [FAMILY.BSU, PROPERTY.BSU] = [B(F), B(p)] is added to Property Applicability Sheet, and

(iii) if a property p with BSU code B(p) is used for a simple family F with BSU code B(F), then the row of the form [FAMILY.BSU, PROPERTY.BSU]=[B(F), B(p)] is added to Property Applicability Sheet.

To see how to construct this Sheet, for example, consider properties 1 (UOHP001) through 4 (UOHP004), by which family X (UOH001) is defined by using Table 3 such that each class in X has the same set of properties 1 through 4. Thus, by (ii) four rows [UOH001, UOHPk] (k= 001, 002, 003, 004) are added to Property Applicability Sheet, as shown in Table 6. Now, consider property 14 (UOHP014), which is used for five classes C1, C2, D, E, and H, as can be seen from Table 3. A set of the first four

Table 6: Property Applicability Sheet

FAMILY.BSU	PROPERTY.BSU
UOH001	UOHP001
UOH001	UOHP002
UOH001	UOHP003
UOH001	UOHP004
UOH003	UOHP005
UOH003	UOHP006
UOH003	UOHP007
UOH003	UOHP008
UOH003	UOHP009
UOH003	UOHP010
UOH004	UOHP011
UOH004	UOHP012
UOH004	UOHP013
UOH004	UOHP014
UOH011	UOHP014
UOH008	UOHP015
UOH008	UOHP016
UOH002	UOHP017
UOH009	UOHP017
UOH011	UOHP017
UOH009	UOHP018
UOH011	UOHP018
UOH002	UOHP019
UOH007	UOHP020

classes C1, C2, D, and E constitute a generic family Z (UOH004), which is defined such that each class in Z has the same set of properties 11 through 14, and hence by (ii) four rows [UOH004, UOHPk] (k=011,012,013,014) are added to the Sheet as shown in Table 6; while H(UOH011) constitutes a simple family, and hence by (iii) a row [UOH011, UOHP014] is added to the Sheet, as shown in Table 6.

4. Transformation of three Excel Sheets to EXPRESS Specification

The process of **[Phase II]** stated in **3.** is executed by means of an automatic mapping scheme as follows. Essentially, the mapping is performed according to the rules of ISO13584-42 [1] and ISO 10303-11[2] .

4.1 Mapping of Family Sheet

The process of mapping the entries in Family Sheet of Table 4 onto instances of the EXPRESS specification is outlined as shown in Fig 2. At this stage a difficult aspect of this process consists in what way these entries are mapped onto instances of the EXPRESS specification. To this end, we have to take account of the common ISO/IEC dictionary schema [1], which prescribes

(a) the attributes that shall be provided by library data suppliers to describe the families and properties of chains, and
(b) the specifications of those attributes in the EXPRESS information model which provides for the exchange of such dictionary data.

```
procedure TRANSFORMATION OF FAMILY SHEET TO
EXPRESS SPECIFICATION
begin
  while there is an unprocessed row in Family Sheet do
    for each unprocessed row i do
      begin
        instantiate a Component_Class of family K with the
            BSU code at (row i, column CODE)
        add to the Component_Class of family J with the BSU
            code at (row i, column PARENT) the parent-child
            relation between families J and K
        add to the Component_Class of family K the name of
            family K at (row i, column PREFNANE.EN)
      end
end
```

Fig. 2 Outline of mapping of entries in Family Sheet of Table 4 onto instances of EXPRESS specification

In fact, ISO13584-42 [1] provides the attributes to be used for describing different dictionary elements in the EXPRESS specification. The attributes to be applied to the entries in Family Sheet of Table 4 are selected as shown in Table 7. The one-to-one correspondence between these attributes and the columns of Family Sheet, that is, the assignment of which attribute is to be applied to which column, is prescribed.

Table 7: Attributes for Family Sheet

Attributes	Mapping of entries in Family Sheet onto the common ISO/IEC dictionary schema
Superclass	**component_class\class.its_superclass**
Code	**component_class\dictionary_element.identified_by \basic_semantic_unit.code**
Preferred Name	**component_class\class_and_property_ele-ments.names\item_names.preferred_name**

Specifically, in the actual process of executing the procedure of Fig 2, the following steps are conducted for each row i of Family Sheet of Table 4:

Step 1: Apply "**Superclass**" of Table 7 to the entry at (row i, column PARENT) of Table 4.
Step 2: Apply "**Code**" of Table 7 to the entry at (row i, column CODE) of Table 4.
Step 3: Apply "**Preferred Name**" of Table 7 to the entry at (row i, column PREFNAME.EN) of Table 4.

The application of the attributes of Table 7 to entries in Family Sheet of Table 4 is exemplified as follows.

Consider the 3rd row of Family Sheet, to which the application of these three steps yields the following:

[Step 1]: 'UOH001' is read, and **Superclass**=UOH001 is stored at **component_class\class.its_superclass**.

Here, it should be remarked that **component_class** and **class.its_superclass** indicate instances as well as mapped locations of the EXPRESS specification. In fact, **component_class\class.its_superclass** represents the inclusion hierarchy of instances and mapped locations such that the instance and location of **class.its_superclass** should be specified within those of **component_class,** respectively. Thus, in the above Step 1, "UOH001 is stored at **component_class\class.its_superclass**" indicates that UOH001 is stored at the location of **class.its_superclass** within that of **component_class**.

[Step 2]: 'UOH003' is read, and **Code**=UOH003 is stored at **component_class\dictionary_element.identified_by\basic_semantic_unit.code.**

[Step 3]: 'Roller & Bush chains' is read, and **Preferred Name**='Roller & Bush chains' is stored at the location of **component_class\class_and_property_elements.names\item_names.preferred_name**.

4.2 Mapping of Property Sheet

The process of mapping the entries of Property Sheet of Table 5 onto instances of the EXPRESS specification is outlined as shown in Fig. 3. Those attributes provided by ISO 13584-42 [1] which are to be used for mapping the entries in Property Sheet onto instances of the EXPRESS specification are shown in Table 8.

Specifically, for each unprocessed row i in the process of Fig. 3, apply the following steps:

Step 1: Apply the attribute of "**Definition Class**" of Table 8 to the entry at (row i, column FAMILY. BSU).
Step 2: Apply "**Code**" of Table 8 to the entry at (row i, column CODE).
Step 3: Apply "**Preferred Name**" of Table 8 to the entry at (row i, column PREF-NAME.EG).

For example, the application of these attributes of Table 8 to the 1st row of Property Sheet of Table 5 yields the following:

[Step 1]: 'UOH001' is read, and **Definition Class** ='UOH001' is stored at **property_DET\dictionary_element.identified_by\property_BSU. name_scope**.

```
procedure TRANSFORMATION OF PROPERTY SHEET TO EXPRESS SPECIFICATION
begin
  while there is an unprocessed row in Property Sheet do
    for each unprocessed row i do
      begin
        instantiate a Property_DET of property P with the BSU
          code at (row i, column CODE)
        add to the Property_DET of property P the information
          of applicability of property P to family F with the
          BSU code at (row i, FAMILY.BSU)
        add to the Property_DET of property P the name of
          property P at (row I, column FREFNAME.EN)
      end
end
```

Fig. 3 Outline of mapping entries in Property Sheet of Table 5 onto instances of EXPRESS specification.

Table 8: Attributes for Property Sheet

Attributes	Mapping of entries in Property Sheet onto the common ISO/IEC dictionary schema
Definition Class	**property_DET\dictionary_element.identified_by\property_BSU. name_scope**
Code	**property_DET\dictionary_element.identified_by\basic_semantic_unit.code**
Preferred Name	**property_DET\class_and_property_elements.names\item_names.preferred_name**

[Step 2]: 'UOHP001' is read, and **Code**='UOHP001' is stored at **property_DET\dictionary_element.identified_by\basic_ semantic_ unit.code**.

[Step 3]: 'Chain Number' is read, and **Preferred Name** ='Chain Number' is stored at **property_DET\class_and_property_elements.names\item_names.preferred_name**.

4.3 Mapping of Property Applicability Sheet

The process of mapping the entries in Property Applicability Sheet of Table 6 onto instances of the EXPRESS specification is outlined as shown in Fig. 4. Considering that the key information of Table 6 is the linkage between properties and families, the main work here is to link each property to its applicable families. Thus, among the attributes provided by ISO13584-42 [1], only one of Table 9 is applied to each entry at each row i of Property Applicability Sheet of Table 6 as follows.

Table 9: Attribute for Property Applicability Sheet

Attribute	Mapping of entries in Property Applicability Sheet onto the common ISO/IEC dictionary schema
Applicable Properties	**component_class\class.described_by**

```
procedure TRANSFORMATION OF PRPERTY APPLICA-
BILITY SHEET TO EXPRESS SPECIFICATION
begin
  while there is an unprocessed row in Property Applicability
    Sheet do
     for each unprocessed row i do
       begin
          add to the Component_Class of family F with the
              BSU code at (row i, column FAMILY.BSU) the
              applicability of the BSU code at (row i, column
              PROPERTY. BSU)
       end
end
```

Fig. 4 Outline of mapping entries in Property Applicability Sheet of Table 6 onto instances of EXPREE specification

Specifically, in executing the process of Fig. 4, the attribute of "**Applicable Properties**" is applied to each row i of Property Applicability Sheet in the following way.

Step 1: Let E be the entry at (row i, column FAMILY. BSU) of Table 6, identify the location of **component_ class** at which E is stored, and let this identified location be F.**component_class.**
Step 2: Add the entry at (row i, column PROPERTY. BSU) to the location of F.**component_class\class. described_by** as its applicable property.

For example, the application of this attribute to the 1st row in Property Applicability Sheet yields the following:
[Step 1]: 'UOH001' at (row 1, PROPERTY. BSU) is read, and seek the location of **component_class** at which UOH001 is stored. Let this location be F.**component_ class**.
[Step 2]: 'UOHP001' at (row 1, PROPERTY.BSU) is read, and **Applicable Properties**='UOHP001' is stored at F.**component_class\class. described_by**.

5. Transformation of EXPRESS Specification to STEP Physical File

The final process of **[Phase III]** stated in **3.** is described in what follows. This work is essentially to encode the instances of the EXPRESS specification according to the so-called STEP physical file format, formally called "Clear Text Encoding of the Exchange Structure" [3]. This ISO10303-21-formatted file is constructed of HEADER, section, and DATA section.

The HEADER section is composed of FILE DESCRIPTION (PLIB Dictionary of Chains), FILE NAME (Chain Dictionary compiled by the authors), and FILE SCHEMA (ISO 13584_IEC61360 Dictionary Schema).

The DATA section is constructed by the following two steps.

STEP 1: Assign an instance_number to each instance of EXPRESS specification
STEP 2: Encode each instance according to the prescribed rules.

Specifically, these two steps are outlined as shown in Figs. 5 and 6, respectively. For example, assume a simplified EXPRESS information model, in which the entries of columns PARENT, CODE, and PREF-NAME.EN at the 1st and 2nd rows of Family Sheet of Table 4 are mapped onto the instances, say A, B, and C, respectively, within the Component_Class of Fig. 2. Then the application of Clear Text Encoding to these instances yields the result as illustrated in Table 10.

```
procedure ASSIGNMENT OF INSTANCE NUMBER
var
  instance_number : integer;
begin
  instance_number ←0;
  while there is an unprocessed instance in the EXPRESS
     specification do
      for each unprocessed instance K
         begin
            instance_number of K ← instance_number;
            instance_number ← instance_number + k (a
              constant integer)
         end
end
```

Fig. 5 Outline of assigning entity instance name to entity

```
procedure CONSTRUCTION OF DATA SECTION
begin
while there is an unprocessed instance in the EXPRESS
    specification do
      for each unprocessed instance K
         begin
            write '#', instance_number of K, '=', and
              instance_name of K
            write '('
            for each attribute A of instance K
               begin
                  if A is entity data type then
                      write '#', instance_number of A
                  else
                      write value of A
                  if there remains an unprocessed attribute then
                      write ','
               end
            write ');'
         end
end;
```

Fig. 6 Outline of constructing DATA section

Table 10: Example of Clear Text Encoding of instances within Component_Class

Instances COMPONENT_CLASS			STEP physical file
A	B	C	
null ($Root$)	UOH001	Chains	#10=PROPERTY_CLASS($,'UOH001', 'Chains');
UOH001	UOH002	Flat top chain	#20=PROPERTY_CLASS(#10, 'UOH002','Flat top chain');

Now, assume a simplified EXPRESS information model, in which the entries of columns FAMILY.BSU, CODE, and PREFNAME.EN at the 1st and 2nd rows of Property Sheet of Table 5 are mapped onto the instances, say U, V, and W, respectively, within a Property_DET of Fig. 3. Then the application of Clear Text Encoding to these instances of Property_DET yields the result as illustrated in Table 11.

Table 11: Example of Clear Text Encoding of instances within Property_DET

Instances of PROPERTY_DET			STEP physical file
U	V	W	
UOH001	UOHP001	Chain Number	#30=PROPERTY_DET (#10,'UOHP001','Chain Number.');
UOH001	UOHP002	Pitch	#40=Property_DET (#10,'UOHP002','Pitch');

The application of the above transformation scheme to the instances of the EXPRESS specification yields the final STEP physical file of 'Chains', a part of which is shown in Fig.7.

```
《 ISO-10303-21 Conforming Physical File 》
HEADER;
FILE_DESCRIPTION(('PLIB_CHAINS_DICTIONARY by
  Graduate School of Applied Informatics,','University of Hyogo
  \X2\3000\X0\'),'2;1');
FILE_NAME('PLIB_CHAINS_DICTIONARY0803023.P21','2009-
  08-10',('Saburo TANATSUGU, Mamoru KAWANOBE, Isao
  SHIRAKAWA, and Hiroshi NINOMIYA '), ('Graduate School of
  Applied Informatics, University of Hyogo\X2\3000\X0\'),
  'Dictionary Tool 1.0', 'Dictionary Tool', 'Graduate School of
  Applied Informatics, University of Hyogo\X2\3000\X0\');
FILE_SCHEMA(('ISO13584_IEC61360_DICTIONARY_SCHEMA'
  ));
ENDSEC;

DATA;
#1614=DATES('2009-08-10','2009-08-10','2009-08-10');
#1013=PRESENT_TRANSLATIONS(('en','ja','zh'));
#1007=PRESENT_TRANSLATIONS(('ja'));
#1001=GLOBAL_LANGUAGE_ASSIGNMENT('ja');
#1620=SUPPLIER_BSU('9999/UOH',*);
#1619=SUPPLIER_ELEMENT(#1620,$,'001',#1617,#1618);
#1617=ORGANIZATION('UOH','Universityof
HYOGO','Description');
#1618=ADDRESS('Internal Location','Street Number', 'Street',
  'Postal Box','Town','Region','Postal Code','Country','Facsimile',
  'Telephon','email','Telex');
#1615=CLASS_BSU('UOH001','001',#1620);
#1616=COMPONENT_CLASS(#1615,#1614,'001',#1613,TEXT(''),
  $,$,$,$,(#1373,#1358,#1329,#1301),(),$,(),(),$);
#1613=ITEM_NAMES(#1612,(),#1610,$,$);
#1610=TRANSLATED_LABEL(('Chains','\X2\30C130A730FC30F3
  \X0\','\X2\94FE6761\X0\'),#1013);
#1069=PROPERTY_BSU('UOHP017','001',#1615);
#1070=NON_DEPENDENT_P_DET(#1069,#1614,'001',#1068,
#1063,$,#1061,#1059,$,(),$,$,#1057,$);
#1068=ITEM_NAMES(#1067,(),#1065,$,$);
#1067=TRANSLATED_LABEL(('Maximum plate depth','\X2\30D7
  30EC30FC30C89AD83055\X0\','\X2\94FE677F9AD85EA6\X0\'),
  #1013);
#1063=TRANSLATED_TEXT(('\X2\30D730EC30FC30C89AD8305
  5\X0\'),#1007);
#1057=REAL_MEASURE_TYPE('NR3..3.3ES2',#1056);
#1056=DIC_UNIT(#1055,$);
#1055=SI_UNIT(*,.MILLI.,.METRE.);
#1301=PROPERTY_BSU('UOHP004','001',#1615);
#1302=NON_DEPENDENT_P_DET(#1301,#1614,'001',#1300,#12
  95,$,#1293,#1291,$,(),#1275,$,#1289,$);
#1300=ITEM_NAMES(#1299,(),#1297,$,$);
#1297=TRANSLATED_LABEL(('Maximum width over bering
  pins','\X2\30D430F395773055\X0\','\X2\95008F7451685BBD\X0\
  '),#1013);
#1291=TRANSLATED_TEXT(('\X2\30D430F395773055\X0\'),#100
  7);
#1275=REFERENCED_GRAPHICS(#1282);
#1289=REAL_MEASURE_TYPE('NR3..3.3ES2',#1288);
#1288=DIC_UNIT(#1287,$);
#1287=SI_UNIT(*,.MILLI.,.METRE.);
#1329=PROPERTY_BSU('UOHP003','001',#1615);
#1330=NON_DEPENDENT_P_DET(#1329,#1614,'001',#1328,#13
  23,$,#1321,#1319,$,(),#1303,$,#1317,$);
                    .......... (to be continued) ...........
```

Fig. 7 A part of the final result of STEP physical file

6. Concluding Remarks

The present paper has described a sophisticated procedure of compiling a PLIB dictionary dedicatedly for a mechanical element of 'Chains'. This compilation procedure is distinctive in that not only the key information on families and properties of chains is organized into three Excel Sheets, but also the whole process of (i) mapping the entries in the Excel Sheets onto instances of the EXPRESS specification and (ii) transforming them to a STEP physical file is automatized. The rest of our compilation work is to enhance the degree of completeness of the proposed mapping scheme for the mechanical element of chains.

On the other hand, the PLIB standard (ISO 13584) and STEP standard (ISO 10303) can be recognized as specifications that enable unambiguous exchange of intelligent electronic catalogs among different software systems. However, these specifications are software-developer oriented, and are hardly usable for component-suppliers to describe their own catalogues [16].

Thus, the goal of our future work should be

(a) to extend the proposed architecture of compiling a PLIB dictionary so as to be applied to any other mechanical element, and
(b) to integrate component-supplier oriented tools for different mechanical elements to generate the exchange format of disparate PLIB/STEP-compliant catalogues.

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Saburo Tanatsugu received the B.E. degree in Economics from Otemon Gakuin University, Osaka, in 1975. He joined Kyoiku Gear Corp. in 1989, where he developed a CAD/CAM system for the mechanical design of gears. He has been an Expert Member of ISO TC184/ SC4/WG2 since 1991, was a Liaison Member of ISO TC29/WG34 during 1996-2006, and has been an Expert Member and a Maintenance Agency Expert of ISO TC29/WG34 since 2007. He is now a Ph.D. student at Graduate School of Applied Informatics, University of Hyogo, Kobe, Japan, where he has been engaged in the study of compiling PLIB dictionaries.

Mamoru Kawanobe received the B.E. degree in Mechanical Engineering from Tokyo Institute of Technology in 1981. Since 2000 he has been with Benic Solution Corp., where as a computer scientist he is now engaged in information processing related to ISO standardization. He is now a Japanese Expert of ISO TC184/SC4/WG2.

Isao Shirakawa received the B.E., M.E., and Ph.D. degrees in Electronic Engineering from Osaka University, Japan, in 1963, 1965, and 1968, respectively. He joined Faculty of Engineering, Osaka University, as a Research Assistant in 1968, and was promoted to an Associate Professor in 1973 and to a Professor in 1987, where he worked as the Dean in 2001-2002, and is now a Professor Emeritus. Since 2004 he has been a Professor of Graduate School of Applied Informatics, University of Hyogo, Japan, where he was the Dean in the academic years of 2004 through 2008. Meanwhile, in the academic year of 1974-1975, he was a Visiting Scholar at the Electronic Research Laboratory, University of California, Berkeley. Prof. Shirakawa is now the Chairman of the board of directors of Japan Data Center Council, and served as a Vice President of IEICE in 2004 and 2005 and a Director of the Editorial Board of IEICE of Japan in 1996 and 1997. He also worked as the Chair of IEEE Region 10 Industry Liaison Committee in 2007 and 2008, the Chair of IEEE Kansai Section in 2002 and 2003, a Vice President of IEEE CAS Society in 1995 and 1996, and the Chair of IEEE Region 10 Student Activities Committee in 1993 and 1994. He has been engaged in the education and the research mainly on circuit theory, graph theory, VLSI CAD, VLSI architecture, RFID system, and compilation of PLIB dictionaries. He is now a Fellow and an Honorary Member of IEICE, and a Life Fellow of IEEE.

Hiroshi Ninomiya received the B.E., M.E., and Ph.D. degrees in Applied Physics from Fukuoka University, in 1977, 1979, and 1991, respectively. From 1980 to 1994, he worked as a Research Associate in Faculty of Science, Fukuoka University. From 1994 to 1998, he was an Associate Professor in Faculty of Science, University of the Ryukyu. From 1998 to 2004, he was Professor in School of Human Science and Environment, Himeji Institute of Technology. Since 2004 he has been a Professor of Graduate School of Applied Informatics, University of Hyogo.